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ABSTRACT

This volume is the second half of a final report of a project concerned with developing indepth metric teaching units in the areas of carpentry and machine shop, preparing instructional materials to teach metrics in Spanish, and developing three-dimensional metric instructional materials and cassette tapes for persons with reading difficulties and sight handicaps. The volume contains the metric instructional materials developed for persons with reading difficulties and sight handicaps including an article on metrics for the visually impaired, guidelines for developing learning kits to teach metrics to students with low aptitudes or reading difficulties, and a handbook on teaching metrics to the sight handicapped. Conclusions and recommendations from the total project, presented at the end of this volume, emphasize the following: All State and city courses of study in vocational education should be re-evaluated to determine the amount of metrics that should be included in each of these study areas. Plans should be made to provide curriculum makers with up-to-date information on metric standards. Inservice training is essential in a well-planned, coordinated effort of metric conversion in vocational education. Metric materials in foreign languages should be made available to those groups who can use them. Ample funds must be provided in all areas of vocational education to purchase measuring tools and conversion equipment. The metric kits developed for persons with reading difficulty should be reproduced on a commercial basis. The three-dimensional material for persons with sight handicaps should be reproduced in quantity and made available at a low cost to all school programs for the blind. The most common weakness of most curriculum projects is the lack of adequate dissemination. There should be a followup study to refine and reevaluate the materials for persons with reading difficulty and for those with sight handicaps. (LAS)

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FINAL REPORT

Volume II of Two Volumes

Project No. V0151VZ
OE Grant No. OEG-0-74-1661

METRIC CONVERSION IN VOCATIONAL EDUCATION

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Section 4

METRIC INSTRUCTIONAL MATERIALS FOR PERSONS WITH READING DIFFICULTY

One of the four major purposes of this study is listed in the proposal as follows:

> "To develop simple metric conversion material for persons with reading difficulty. It is proposed that specialists for persons having reading difficultity review the current instructional material that is currently available in metrics from the Center and revise and rewrite the material necessary for those who need more of a visual approach."

It was decided that the best consulting service for this project could be obtained from the Human Resources Research Organization using the staff from the HumRRO Division III in California. This particular group has done extensive work with the military services as well as educational institutions to recommend methods and techniques of training military personnel to do specific jobs. Some of the research they have done involving persons with reading difficulties and with low aptitudes for training include the following:

Aptitude Level and the Acquisition of Skills and Knowledge in a Variety of Military Training Tasks. The George Washington University. Human Resources Research Organization, May, 1969.

Effects of Aptitude (AFQT), Job Experience, and Literacy on Job Performance: Summary of HumRRO Work Units UTILITY and REALISTIC. Alexandria, Virginia. Human Resources Research Organization, February, 1971.

Instructional Strategies for Training Men of High and Low Aptitude. Alexandria, Virginia. Human Resources Research Organization, April, 1973.

Literacy Research for the U.S. Army: Developing Functional Literacy Training. Alexandria, Virginia. Human Resources Research Organization, December, 1973.

Results of this research, which can be summarized as follows, are:

1. There is a direct relationship between reading ability and skill tasks
2. Reading ability, listening ability and arithmetic skills are found to be related to job performance as measured by job knowledge tests and job sample tests
3. In comparison with the abilities and performance of Negroes and Caucasians, no relationship was found between race and performance
4. Peer-instruction formats were effective with slow learners, especially in testing specific skills
5. Hands-on kinds of learning experiences are more effective than the programmed learning instructions.

It was decided, therefore, that in developing the instructional strategies for this important aspect of the project, an agreement with HumRRO would be made for them to serve as consultants for this phase of the work. The actual work was done in conjunction with Dr. Hilton M. Bialek, who has completed a great deal of research in this area. At a meeting in July, 1974, with Dr. Bialek and Dr. Howard McFann, discussions were held concerning the best way to proceed with this aspect of the project. It was unanimously agreed that based on previous research the first step should be to develop some hands-on learning kits that could be used with individuals who are having difficulty obtaining instructions from the written page.

After considerable discussion regarding the form that they should take, it was recommended that several different learning kits be developed. As a result of this, the Director of the project hired wood technologists and metal technologists to actually build kits of materials.

A typical kit, for example, was linear measurement to the closest centimetre. This is the simplest of all kits and included a series of rectangular blocks of wood and plastics cut to exact centimetre dimensions. Since the centimetre is a fairly large unit in metric measurement and it is used primarily for body measurement and for clothing, it was believed that this should be the first basic kit to be developed. The kit included the following materials:

1. Box to house the blocks
2. Series of blocks that were clearly marked A, B, C,

D and so forth and are color coded for ease in determining what measurements to take

3. A ruler divided into centimetres only. This is the most simple metric rule, in which each centimetre is clearly marked with alternate bands of color

4. A recording sheet, which allows the student to record his answer

5. An answer sheet that could be used over the recording sheet to quickly check the answers.

The additional kits, which were similar in nature and type, included measurement to the nearest millimetre, measurement to the nearest millimetre of disks using a vernier caliper, measuring various types of fasteners to the nearest millimetre, reading a print and assembling three boxes of different sizes from parts included in the kit, assembling a metal machinist's clamp using parts that are correct and some that are incorrect and weighing common materials.

In developing the materials a set of guidelines were used as shown as Figure 4-1.

In addition to the kits themselves, it was decided to develop a slide/cassette tape series that could be used to explain metric measurement and the various kits involved. A copy of this script appears as Figure 4-2.

Once these materials were developed, it was decided to evaluate them by field testing. The location for these field tests was the State Technical Institute and Rehabilitation Center at Pine Lake, Michigan, which was formerly called the Michigan Rehabilitation Center. This school was founded specifically for preparing students with physical and mental handicaps for various occupations. All students are enrolled in job-oriented programs such as carpentry, machine shop, upholstery, floor covering, watch repair and so forth.

Mr. John Evers, a doctoral candidate at the Center for Evaluation at Western Michigan University, was employed to do the actual on-site evaluation. However, before this was done he made an analysis of the meaning of evaluation as related to the Center for Metric Education and testing of training materials. This analysis appears as Figure 4-3.

As the first step in evaluation the Director of the Center for Metric Education and Mr. John Evers spent a half day session with the staff of the technical programs at the State Technical Institute to cover the problem of planning a metric education training program and to explain the research to be carried out. As part of this research

activity, two slide series were presented. The first was titled Planning a Metric Education Program and the second, a review of the material included in the kits, was entitled Reading a Metric Rule, which was developed for teaching the students the basic unit of length, and how to utilize it in the kits.

Following the presentation, Mr. John Evers worked with the personnel in the reading lab to carry out experiments with twenty-three individual student enrollees. The results of his two-month study follow.

RESULTS OF A PILOT TEST ASSESSMENT OF METRIC EDUCATION INSTRUCTIONAL MATERIALS DEVELOPED FOR SLOW LEARNERS

The evaluator conducting the study was directly contracted by the Center for Metric Education.* He was charged to conduct a pilot test of the materials at one or two sites; using the materials with individuals similar to those originally targeted in the proposal. Information from the pilot test would serve two purposes:

1. to diagnose strengths and weaknesses of the present form of the materials, and
2. to investigate potential parameters of ability that could define future successful users of the materials.

Therefore, in technical terminology, the overall purpose of this report is to provide formative information about results.

Formative information about results focuses on the merit of outcome produced by the instructional materials. However, since the materials have not benefited from any previous evaluation activities, the results reported here are for further revision and improvement of the materials rather than hard-line comparison of a finished product. Throughout the report the perspective presented is from an individual who was not involved in the production of the instructional materials. Therefore, a potential strength of this report is its external and independent viewpoint.

Another preliminary consideration is that the materials tested had undergone a shift in orientation from individuals with reading difficulties to individuals with learning difficulties. The materials were, therefore,

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*John W. Evers, Evaluation Consultant

broadened in focus from what was originally proposed. To accommodate the special needs of this group of individuals, the Center had implemented a strategy suggested by one of its external content consultants. This suggestion focused on manipulative, concrete, individualized activities with little or no reading necessary. Therefore, the materials were developed in the form of individual kits each focusing on one facet of the metric system. Individual learners were given a series of practice exercises that would familiarize them with using various metric measuring instruments without having to read any narrative. When the materials were in first finalized form, the project staff proposed that potential users of the kits would be those considered as "slow learners". However, when probed, the Center staff was unsure about what defined a slow learner or exactly what ability level the kits could be used with. Therefore, as previously mentioned, this shift in target population from reading difficulties to slow learners opened an investigation of ability levels within the pilot test or the range of ability that could constitute a slow learner with these instructional materials.

Overview of the Pilot Test

The Director of the Center for Metric Education proposed potential sites for the pilot test. The one selected was at the State Technical Institute and Rehabilitation Center in Plainwell, Michigan. Contact was made between the Center and the State Technical Institute and Rehabilitation Center in March, 1975, establishing them as a cooperative site for evaluation. A general inservice session was presented to the State Technical Institute and Rehabilitation Center staff concerning the metric system and the purpose of the evaluation. As a brief digression, it should be useful to consider basic descriptive elements of the State Technical Institute and Rehabilitation Center and its student body.

This vocational rehabilitation center was established in 1944 and operates on about a 2.2 million dollar budget per year with eighty percent federal funds and twenty percent state funds. Overall capacity and staff are fourteen training departments, four hundred thirty five training stations, thirty seven trade-related instructors and one administrator. Of graduating students, sixty percent are employed at graduation, ninety percent are employed one year after graduation, and ninety seven percent are employed two years after graduation. About thirty to thirty five percent of its students drop out of the program, but fifty percent of the dropouts are employed also.

This presents a general overview of the capacity, orientation, and success of the school as of September, 1974. It should be useful to also consider the nature of the student body.

The following presents two descriptions of the student body. The 1973-74 School Year information is based on four hundred fifty five students and the September, 1974, information is a description of the two hundred three new, incoming students in September, 1974.

1973-74 School Year

67% single
33% married, or have been
26.8 is the average age
61% graduated from high school
5.7% females
15% minorities
34.5% have orthopedic disorders
30.5% have personality disorders
5.0% have hearing disorders
2.0% have extremety loss
4.0% have visual disorders
24.0% have other disorders
94% are VRS supported
3% are VA supported
1% are institutionally supported
2% are privately supported

September, 1974

60% single
40% married, or have been
26.2 is the average age
69% graduated from high school
9% females
13% minorities
30% have orthopedic disorders
25% have personality disorders
9% have hearing disorders
1% have extremety loss
5% have visual disorders
30% have other disorders
89% are VRS supported
3% are VA supported
4% are institutionally supported
3% are privately supported

Individual descriptive information will be presented later for those students participating in the pilot test.

After the general orientation with the State Technical

Institute and Rehabilitation Center staff, contact has focused on a few teachers and their students. Students who have difficulties with math and reading are sent to the Learning Resource Center by their job-related teachers for remedial work in these two areas. Based on discussions with these teachers and staff members of the Center, it was assumed that students referred to the Learning Resource Center for remedial math and reading would constitute an appropriate target group for the instructional materials developed for slow learners. The concept of metrics and the issue of metric conversion was at best vaguely familiar to a few individual students because of job-related experiences, but in general was unknown.

Students were selected through consultation between the math and reading teachers and the evaluator. Two criteria for selection were imposed. First, students should be primarily selected from the lowest ability levels possible so that developers of the kits could get a general idea of the minimal ability needed to master the materials. In another sense this would allow an inference to be made about how slow a learner could be and still achieve mastery of the material. It could then be assumed that once a bottom ability could be estimated, individuals above this bottom ability level would master the materials in a direct relationship with their increased ability. To consider this possibility, a few individuals were tested that were of a high ability level.

The second criterion imposed for the selection of students was to cover as many vocational fields as possible within the training areas at the State Technical Institute and Rehabilitation Center. This would attempt to reduce any bias that may be due to specific vocational areas. It was estimated that approximately forty to fifty students would fall into these categories of low ability levels and diverse occupations. Considering the procedures of the pilot test, forty to fifty students was an adequate number to work with.

Seven kits were available to be tested. They covered use of the centimetre ruler, the millimetre ruler, the millimetre calipers (as two kits), box construction, clamp construction, and use of weights. Also included was a slide/tape presentation to be used along with the kits primarily as an introduction to the series. Since the instructional materials had not been used previously by slow learners, there was no estimate of the amount of time needed per kit or the amount of instruction needed

to orient the student. Therefore, students were involved with the materials one at a time to provide a more careful monitoring of the instructional process. Working with individual students one kit at a time reduced the potential number of individuals that could be involved in the pilot test. However, since this was an investigatory pilot test and not an extensive field test, a large quantity of individuals was not crucial.

Twenty-three students were involved in the pilot test. Some were involved with all materials, but most sampled from the seven kits and the slide/tape presentation. An average time involvement was one and a half hours per student. A logical analysis of the materials prior to usage considered the kits to fall into two groupings. The first grouping seemed easiest and was made up of the centimetre ruler, millimetre ruler, two kits using the millimetre calipers, and the slide/tape series. The second grouping was assumed more difficult because of a needed prerequisite knowledge of blueprints. It consisted of the clamp and box construction kits. Therefore, those students that were chosed for a low ability in math and reading were started with the easier set of kits and allowed to progress as far as possible through the materials. Those who stopped short of mastering the entire range of kits either worked to a point where they became frustrated with the task or were stopped short by the evaluator who observed that the student was unable to begin the required exercises or ran out of time available in the Learning Resource Center.

As the following chart portrays, some individuals who were of a higher ability level started with the more difficult kits and superficially reviewed easier materials for content. The left-hand column presents individuals by subject number whereas the top horizontal presents the kit used. Taken in combination it presents a matrix of subjects by kits and portrays a sampling plan implemented for the study.

MATERIALS

Subject	Slide Tape	cm Ruler	mm Ruler	mm Disks	mm Fasteners	Box Plans	Clamp Plans	Weight
1		x	x	x	x	x	x	x
2		x	x	x				
3		x	x	x	x			
4		x	x	x		x	x	x
5				x		x	x	
6						x	x	x
7	x	x	x					
8	x	x	x	x		x		
9	x	x	x		x			
10	x	x	x					
11	x	x	x		x			
12	x			x		x	x	
13	x			x		x		x
14	x	x	x	x	x			
15	x	x						
16	x	x	x	x				
17	x	x	x		x			
18	x	x	x					
19	x	x	x					
20	x	x	x	x		x	x	x
21						x	x	
22						x	x	x
23	x	x		x				

Next, descriptive data will be presented about each student in the study. Included are sex, race, age, reading and math grade level scores, IQ score (if available), type of handicap, and other background data available.

Subject 1 - Andy K.
- White male, 24 years old
- Reading ability - 7th grade level
- Math ability - 5th grade level
- Average IQ
- No physical or mental handicaps but diplexia
- Completed 10th grade
- A machine shop major, first year

Subject 2 - Bill H.
- Black male, 22 years old
- Reading ability - 11th grade level
- Math ability - 2nd grade level
- Slight retardation
- Speech problems and extreme difficulty with fractions and using the ruler
- Graduated from high school through Special Education
- A first year business education major who was dropped from printing because unable to use ruler

Subject 3 - Karen
- White female, 18 years old
- Reading ability - 6th to 7th grade level
- Math ability - 8th grade level
- Above average IQ
- Deafness
- Completed high school through Michigan School of Deaf in Flint
- A printing major, first semester

Subject 4 - Jim W.
- White male, early 20's
- Reading ability - 9th grade level
- Math ability - 8th grade level
- Average IQ
- No physical or mental handicaps
- Completed high school
- An office machines repair major

Subject 5 - Joe B.
- White male, mid 20's
- Reading ability - 10th grade level
- Math ability - 14.2 grade level
- IQ unknown
- No physical or mental disabilities
- Completed high school
- A graduating senior in drafting

Subject 6 - George C.
White male, 22 years old
Reading ability - 10th grade level
Math ability - 6th grade level
Average IQ
Epilepsy
Completed high school
Third semester in drafting

Subject 7 - Vennie N.
White male, 44 years old
Reading ability - 2nd grade level
Math ability - 2nd grade level
IQ unknown
Slight physical disability - spinal
Completed 7th grade
A first semester custodial major

Subject 8 - Don L.
White male, 40 years old
Reading ability - 7th grade level
Math ability - 6.5 grade level
Average IQ
Slight physical disability - arm
Completed 10th grade
A machine shop major - 2nd semester

Subject 9 - Larry R.
White male, 18 years old
Reading ability - 10th grade level
Math ability - 6.7 grade level
IQ unknown
No physical or mental disability
Completed high school
A machine shop major - 2nd semester

Subject 10 - Rick V.
White male, 18 years old
Reading ability -4th grade level
Math ability - 6th grade level
IQ unknown
Slight head injury from auto accident
Completed high school
A machine shop major - 1st semester

Subject 11 - Ken V.
White male, early 20's
Reading ability - 7th grade level
Math ability - 5th grade level
IQ unknown
Slightly retarded
Highest grade completed - unknown
Custodial major - 1st semester

Subject 12 - Ron B.
White male, 25 years old
Reading ability - 11.3 grade level
Math ability - 15.6 grade level
Average IQ
Hearing loss
Four years of college work
An auto mechanics major

Subject 13 - Dennis V.
White male, 18 years old
Reading ability - 10th grade level
Math ability - 11th grade level
Average IQ
Epilepsy
Completed high school
A dental technology major

Subject 14 - Jim W.
Black male, 36 years old
Reading ability - 7th grade level
Math ability - 5th grade level
Average IQ
Amputee
Completed 8th grade
An auto mechanics major

Subject 15 - Sarah
Black female, 20 years old
Reading ability - 4th grade level
Math ability - 4th grade level
Borderline mentally retarded
Completed 12th grade in Special Education
Pre-vocational printing major

Subject 16 - Dave S.
White male, early 20's
Reading ability - 9.1 grade level
Math ability - 6.5 grade level
Average IQ
Slight physical disability
Completed 8th grade
Pre-vocational auto mechanics

Subject 17 - Margaret
White female, late 20's
Reading ability - 6.5 grade level
Math ability - 4.2 grade level
Below average IQ
Completed high school in Special Education
A printing major

Subject 18 - Dave R.
White male, 21 years old
Reading ability - 4.5 grade level
Math ability - 7.6 grade level
Below average IQ
Slight mental disorder
Completed 7th grade
A machine shop major

Subject 19 - John D.
White male, early 20's
Reading ability - 2nd grade level
Math ability - 4/5 grade level
Slight mental retardation
Completed high school in Special Education

Subject 20 - Don C.
White male, 23 years old
Reading ability - 7th grade level
Math ability - 4th grade level
Below average IQ
Completed 12th grade through Special Education

Subject 21 - Bob P.
White male, 32 years old
Reading ability - 4.3 grade level
Math ability - 5.9 grade level
IQ unknown
Deafness
Completed high school at Michigan School for Deaf
A machine shop major

Subject 22 - Terry M.
White male, 25 years old
Reading ability 5.3 grade level
Math ability - 5.0 grade level
IQ unknown
Deafness
Completed high school at Michigan School for Deaf
A machine shop major

Subject 23 - Greg B.
White male, 20 years old
Reading ability - 5.2 grade level
Math ability - 6.5 grade level
Slight mental retardation
Deafness
Completed high school in Special Education
A custodial major

This overview has presented the general elements of the pilot test. The purpose of the study, the general study plan, the nature of the pilot site, the characteristics of the student body, the material's sampling plan, and the specifics of the subjects have all been presented. Next, the results will be considered and presented in a

series of recommendations to the developers of the instructional materials.

Results and Recommendations

Several sources of information were drawn upon for this report. For example, sources were the students who used the kits, their test results for each kit used, the math and reading teachers at the State Technical Institute and Rehabilitation Center, and the evaluator who conducted the study. Each of these sources was external and independent from the developers of the instructional materials. Results and recommendations are not conclusive or final. They are open to further exploration and should be considered as preliminary hypothesis or estimates of the present merit of the materials. It is the conceptual nature of a pilot test to feed back information to the producers for improvement of their products prior to more extensive dissemination as a field test. Therefore, it is anticipated that information from this report will lead to necessary revisions and further developments of materials.

First of all, the Center for Metric Education is to be commended for attempting to fill a void with instructional materials where little has previously existed. As was reinforced by the staff at the State Technical Institute and Rehabilitation Center, the issue of metric conversion is looming large on the horizon and is pressing hard on vocational rehabilitation centers as they attempt to train individuals for present and future jobs. An increasing percentage of incoming students at the State Technical Institute and Rehabilitation Center (and possibly elsewhere) are considered to be "slow learners". These individuals need remedial instruction in several areas, including orientation to the metric system.

Although other materials exist, the Center's choice of concrete, hands-on experiences as a learning strategy for slow learners has been validated through this pilot test. Repeatedly, by either student or teacher comment, the idea of self contained, experimental projects were both appreciated and praised. Students who had experienced past failure with learning situations became enthusiastic by the immediate reinforcement provided by self-scoring responses within a relatively short period of time.

Across the kits as a group, there is evidence that adult slow learners with reading and math ability levels ranging from second to fourth grade can master the content

of some of the kits. Examples are the slide/tape series and use of the centimetre and millimetre rulers. The millimetre caliper kits can be used at this ability range but with occational frustration due to the need for a conversion of reading the caliper in centimetres and having to write the answers in millimetres. On the surface this would seem to be a simple task for a "normal" learner but caused difficulty at lower ability levels.

Students at this lower ability level were not able to complete the box and clamp construction kits, unless they had previous experience in job-related situations with blueprints. If this previous experience was considered, students at a fourth to fifth grade ability level were successful with the materials that involved blueprint reading. Students at higher ability levels (fifth to eighth) in reading and math or higher had difficulty with these two kits if they had no experience with blueprints, eg, dental technology and printing. Therefore, it appears that past experience is more of a prerequisite for success with the box and clamp construction kits than is math and reading ability. It should be seriously considered that these last two kits test ability to read blueprints rather than ability to use metric measuring devices. If this was not the case, there would be little reason for those who were successful with the millimetre ruler kit to not be successful with the construction kit since both use the same measuring standard. However, it was not found that success on the millimetre ruler was the only prerequisite necessary for success with the box and clamp kits. Another possible consideration is that many individuals considered as slow learners have difficulty working with three dimensional figures in space. Therefore, this mental weakness could limit the usability of the blueprint kits with those individuals who are truly slow learners.

The amount of time needed to complete each kit varied with ability levels and past experience (in the cases mentioned in the last paragraph). A general range of time needed spans from fifteen to forty minutes per kit. This time estimate would cover all the kits tested. It reflects a monitoring of actual time needed to complete the tasks within each kit after a preliminary set of instructions by the teacher and an example problem. That is, no time limits were imposed on the students. They worked until finished.

Test results from the answer sheets found that twenty two out of twenty three students were able to meet the criterion level specified by the developers. The tolerance levels were needed to bring about half of those.

answers into acceptable limits, however. It appears that the plus or minus one millimetre tolerance is needed not because of student errors but because of true physical error in the blocks measured. Therefore, the criterion level and tolerances seem adequate on all kits except the one dealing with weights. This particular exercise uses a weighing instrument that was viewed as "sloppy and inaccurate" by users. Student answers varied as much as two grams from the answer sheet. This error was attributed to the variability of the scale and seen as intolerable for students in precision job areas such as dental technology.

In general, there need be no strict sequencing of the presentation of kits. For those students who reviewed the slide/tape series as an introduction, there was no difficulty in beginning with any of these four kits; cm ruler, mm ruler, mm calipers (two kits). However, those that did not see the slide/tape series as an introduction had difficulty if not started with the centimetre ruler materials. For those not seeing the introduction, the logical successful sequence was to begin with centimetre units and then go to millimetres. On the other hand, those that saw the introduction could start anywhere within the series of four. There was a general problem with starting on the clamp and box kits (as was mentioned previously) regardless of the introduction.

Two immediate revisions can be made to improve the usability of the materials. First, at some lower ability levels there was a strong tendency to place the answers in the wrong columns on the answer sheet. This can be remedied by a simple addition of hash-marks or diagonal lines across the columns that are covered by the answer grid. This makes it more apparent where answers are to go even though the column is labeled "answers" at the top.

Secondly, as was reported during the pilot test to the producers, there are some unnecessary dimensions on the blueprints that can be removed. They were causing distractions in some of the attempts and are not needed to construct the boxes.

As a retrospective gestalt considering all the kits and the results of the pilot test, it is unclear how these instructional materials represent a complete set that would be truly necessary to provide an adequate orientation to the metric system for slow learners. The materials do well in providing an orientation to centi-

metres and millimetres, but it appears that additional kits are needed if there is to be a complete set of instructional materials targeted at slow learners. These additional materials would cover areas of the metric system besides linear measurement.

It is not clear whether there existed a previous plan to develop a full set of instructional materials or materials only related to linear measurement. It would seem that to do an adequate job in developing materials a full range would be necessary to explain the metric system. Considering the realities of limited funds and project staff to do the development, it is unfortunate that much effort appears duplicated in the present form of the materials. The four kits covering use of the centimetre ruler, millimetre ruler and millimetre calipers could easily have been developed as one kit. The synthesized kit would then provide a range of measuring tasks across blocks, disks, and fasteners. Three measuring instruments would be provided within this kit; a cm ruler, a mm ruler and one caliper. The student could be asked to do half of the exercises provided by four kits, and it could be hypothesized that as much learning could take place with one combined exercise as with four separate exercises.

Although the cost of each kit in dollars and manhours is unknown, it can be considered that a considerable savings would have resulted through a combining of the linear measuring kits. This savings would have allowed a more comprehensive set of instructional materials to have been developed with the same amount of dollars and manhours. If funds and time allow it, it is reasonable to consider more development of kits that incorporate the strategy that has shown to be valid with the existing materials. If no funds and time remain, then it is unfortunate that more careful planning was not given to prioritizing actually needed materials and the most efficient means to produce them.

A final consideration is what happens to the materials that currently exist? Too often products of developmental projects collect dust on someone's shelf for lack of funds to disseminate them. Even though the present set of materials does not present an orientation to the whole metric system, they do an adequate job in giving practice with linear measurement for slow learners. If possible, it would seem appropriate to place the materials where they would be used by slow learners. One site immediately comes to mind. Why not give the materials to the State Technical Institute and Rehabilitation Center?

Following this evaluation, materials were sent to Dr. Hilton M. Bialek of the Human Resources Research Organization, who was originally hired as a consultant in this area for further evaluation. Dr. Bialek's comments appear as Figure 4-4.

CONSTRUCTION OF THE LEARNING KITS

Persons interested in the followup of these experiments will find the necessary drawings and instructional materials for these kits beginning on page 29.

Figure 4-1

GUIDELINES FOR DEVELOPING LEARNING KITS TO TEACH METRIC MEASUREMENT TO THE STUDENT WITH LOW APTITUDE AND/OR READING DIFFICULTY

1. The focus of instruction would be on measurement with the metric system being the standard unit.

2. Teach the metric system of measurement only without a comparison to the customary system.

3. Compare the metric measuring system to our money system, which is a decimal system based on units of ten.

4. Students learn best when they have experiences in measuring; therefore, the basic concepts of measurement and the skills and knowledge related to it will be developed by having the students involved in doing activities.

5. Since the metric units of length are the basis for mass, volume and fluid capacity, this would be taught first.

6. Only three length measurements will be used including the metre, centimetre and millimetre. No reference will be made to other multiples and submultiples until the learner has acquired experience in using the system.

7. None of the measuring activities will involve conversion from the metric to the customary system and vice-versa.

8. All materials and measuring instruments will be made to full size, so that actual measurements will be made. No scale drawings or scaled-down parts will be used.

9. After the learner has had experience in using the measuring units, emphasis will be placed on estimating the correct sizes in metrics. For example, what is the height of the door in metres or what is the length of a pencil in millimetres and similar measuring activities.

10. Prefixes for multiples and submultiples will be introduced as they are used.

11. Emphasize the correct use of symbols both in the measuring instruments and in the recorded data.

Figure 4-2

READING A METRIC RULE

1. Along with the rest of the world, the United States is slowly changing its system of measurement from the one we now know and use called the customary (English) system to the metric system. This slide series will teach you how to read a metric rule.

Measurement is the way to find the size, quantity and amount of things. Therefore, measurement is the way of measuring with units.

2. Fortunately, in the metric system the base unit is ten, like the ten fingers on our hand or toes on our feet.

3. In other words, metrics measures by ten.

4. The base unit of length in the metric system is the metre. The metre is just a little longer than the customary yard.

5. The metric system is based on units of ten, just like our money. For example, if a dollar equaled a metre, then ten dimes would be equal to ten decimetres, a hundred cents a hundred centimetres and a thousand mills (a unit we use in taxation) would be equal to a thousand millimetres. A decimetre is 1/10th of a metre, a centimetre is 1/10th of a decimetre and a millimetre is 1/10th of a centimetre.

6. Here is another illustration of how our money and the metric lengths are identical. The base unit of our money is the dollar, and in the metric system the base unit of length is the metre. Measurements larger than the metre are shown above and those smaller below. In everyday life only four units are used--the base unit the metre, the kilometre for long distances to replace the mile, the centimetre is used for body measurements and clothing and the millimetre is the standard unit in industry for making and recording measurements. Even the length of a 747 airplane would be given in millimetres.

Note also that symbols can be used for describing metric units. The small km means kilometre, the small m means metre, the small cm means centimetre and the small mm means millimetre. These are symbols not abbreviations. Therefore, no period is used.

7. Note that the metre is divided into ten decimetres. A decimetre is not used as a measuring unit of length, but is shown here merely to illustrate that metrics is by ten.

8. This rule shows that each numbered line is marked in centimetres. There are ten centimetres in a decimetre (indicated by the large black arrow). Again, metrics is by ten.

9. You can see that there are ten smaller divisions between the numbers one and 2.

10. Each of these smaller divisions is a millimetre. There are ten millimetres in a centimetre. It is easy to visualize what a millimetre is if you think of it as the thickness of a dime.

11. Here you will see two types of metric rules. The wooden rule has every numbered line one, two, three, four, representing centimetres. There are ten smaller divisions between the numbered lines each of which is a millimetre.

Below is a precision metric measuring tool used in metalworking. On the lower half of the rule the numbered lines are marked in millimetres with ten smaller divisions between each of the numbered lines. On the upper half of the rule there are twenty divisions between the numbered lines, each of which is one-half millimetre.

12. Here you see the way rules are commonly marked in metrics. Type 1 shows a rule marked with the numbered lines in centimetres with ten divisions between each numbered line. The smallest division is a millimetre. A cm meaning centimetres is stamped near the end of the rule. Remember that a millimetre is about the thickness of a dime.

Type 2 is a millimetre rule. Each of the numbered lines are marked in millimetres. The rule is stamped mm near the end meaning millimetres. Note the only difference between Type 2 and Type 1 is that a zero must be added to each numbered line to change it from centimetres to millimetres.

In Type 3 and 4 the smallest division is the half millimetre. Type 3 has the numbered lines marked in centimetres while Type 4 has the numbered lines marked in millimetres.

13. In reading a rule marked in centimetres you must

add a zero to a numbered line before you add the additional millimetres. For example, to measure the first line change one to ten and add two millimetres for a total of twelve millimetres. For the second line, change two to twenty and add eight millimetres for a total of twenty-eight millimetres. For the third line, change four to forty and add two millimetres for a total reading of forty-two millimetres.

14. It is easier to use a rule marked in millimetres since you simply add the number of small divisions beyond the numbered line to the number stamped on the numbered line for the total reading. For example, the distance to the first line is ten plus three equaling thirteen millimetres. The second line measures twenty plus four for twenty-four millimetres and the third line forty plus four for forty-four millimetres.

15. To help you learn how to make metric length measurements you will be using a series of kits. These kits are in boxes such as you see here.

16. Here is the material contained in one of the kits. It consists of color-coded blocks, a metric rule and a pencil.

17. Each kit also contains a Teacher's Guide,

18. a Procedure Sheet and

19. a Record Sheet. Instructions for making measurements will be given to you orally by your instructor.

20. The first kit you will be working with is called the centimetre kit and the interior looks like this.

21. Using a centimetre rule you will measure the thickness, length and width of each of a series of blocks numbered A through J. Here you see a centimetre rule being used to measure the length of Block B. Note that the block is nine centimetres long.

22. This kit is called the millimetre kit. It is very similar to the centimetre kit except that all measurements are made in millimetres.

23. Here you see a person measuring the length of Block B with a millimetre rule.

24. This kit contains a series of disks or washers,

a metric caliper, pencil, instructions and a Record Sheet. You must measure the thickness, inside diameter and outside diameter of each of the disks.

25. Here the caliper is being used to measure the inside diameter of Disk A.

26. Here the caliper is being used to measure the thickness.

27. This kit will give you experience in measuring common fasteners. You must measure the length of each fastener in millimetres.

28. This kit contains seventeen parts for assembling three boxes.

29. Each box requires five parts for a total of fifteen. There are two extra parts that are of the wrong size. The kit also contains drawings showing the dimensions of Box A, B, and C. An assembly drawing shows how to assemble the box, a rule for making measurements and pins to assemble the boxes are also included.

30. You must be able to read the drawing, select the correct parts and assemble the box as shown here.

31. This kit will give you experience in reading a drawing and assembling a metal part. The kit contains eight flat clamp parts and six threaded parts for a total of fourteen parts for a machinist's clamp. You must follow the drawings and select the four parts that are necessary. You must measure the flat clamp parts with a rule and select the correct two. You must also use a thread gage to determine the correct diameter and thread pitch in millimetres for the metric threads and then select the correct two. You must assemble the clamp as shown in the center of the picture.

32. Remember, that the metric system is measurement by tens. The base unit of length is the metre. It is divided into ten equal parts called decimetres. One decimetre is one-tenth of a metre. A decimetre is divided into ten equal parts called centimetres. There are one hundred centimetres in a metre and a centimetre is one-one hundredth of a metre. The centimetre is divided into ten equal parts called millimetres. There are one thousand millimetres in a metre and each millimetre is one-one thousandth of a metre.

Now you are ready to use the kits to learn to measure in metrics.

33. The End.

Figure 4-3

AN ANALYSIS OF THE MEANING OF EVALUATION[1]
AS RELATED TO THE CENTER FOR METRIC EDUCATION
AND TESTING OF TRAINING MATERIALS

In order to adequately conceptualize evaluation as it is being used in relation to the testing of materials produced by the Center for Metric Education, the following questions should be considered:

1. What is evaluation in this situation; how is it defined?
2. What purpose does the evaluation serve?
3. What variables does the evaluation consider?
4. What information does it require?
5. Who will it serve?
6. Who is doing it?

These questions will be used as a framework to structure a brief narrative discussion of evaluation of materials in a pilot test made in two or three sites.

1. What is evaluation in this situation; how is it defined?

Generally speaking, evaluation is the assessment of merit. Specifically, it is the assessment of merit of the effects of a set of training materials produced by the Center for Metric Education.

2. What purpose does the evaluation serve?

Evaluation can serve several purposes. However, in this situation, it serves to aid proactive decision making for formative purposes. In other words, it serves to inform future decisions about the nature of the training materials by providing diagnostic information about the materials' strengths and weaknesses under actual operating conditions.

3. What variables are considered?

There are several variables that could be considered. However, in this situation evaluation considers what are called outcome variables of the training materials. Outcome variables consider such things as cognitive and affective achievement, side effects, and impact of the target group involved with the training materials.

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[1]Adapted from materials by Daniel L. Stufflebeam, Director of the Evaluation Center, Western Michigan University.

4. What information does it require?

In this situation, evaluation requires both descriptive and judgmental information. That is, the evaluation requires a description of the outcome variables being considered and a judgment of achievement on those outcome variables by the users of the materials and the evaluator.

5. Who will it serve?

The evaluation will serve three audiences in this study; first, the sponsor of the project (U.S. Office of Education); second, the project staff; and third, staff of the sites where materials are pilot tested. That is, the evaluation will provide information to the U.S. Office of Education about the effects of its grant to the Center for Metric Education. It will provide information to staff members of the Center for Metric Education about the effects of the training materials that they have produced. Also, information will be provided to staff members of the sites cooperating in the pilot testing of the training materials about the merit and effects of the materials produced by the Center.

6. Who is doing it?

The evaluation is being conducted by a staff associate of the Evaluation Center at Western Michigan University. This staff member was not involved in the development of the training materials, and therefore, can be assumed to maintain a degree of objectivity in testing, assessing, and reporting the results of the training materials.

Figure 4-4

HUMAN RESOURCES RESEARCH ORGANIZATION

WESTERN DIVISION

Carmel Office

27857 Berwick Drive
Carmel, California 93921
(408) 625-1347

September 23, 1975

Dr. John L. Feirer, Director
Center for Metric Education
Western Michigan University
Kalamazoo, Michigan 49001

Dear John:

Following are my comments on the "Results of a Pilot Test Assessment of Metric Education Instructional Materials Developed for Slow Learners" prepared for your Center by John Evers.

Although the author points out that "the results...are for further revision and improvement of the materials rather than hard-line comparison of a finished product", the assessment could have been somewhat more systematic and precise. Let me first list what I see as some of the problems with the report and then follow it with some positive comments and my own conclusions.

1. Although the reading and math ability scores are given for each student, it is not possible (from the data presented) to examine what, if any relationship exists between performance on any or all of the kits and these indicies of learning ability.

2. Time to learn or master individual kits for individual students or the group of students who worked with any one kit is not recorded. Thus, we get no clue as to relative difficulty nor any specific information as to success/failure.

3. The interactions between ability level and specific kits and occupational background are not examined even though efforts to control these variables were made.

My overall complaint, therefore, is the failure to collect more precise data and the failure to apply even a quasi-rigorous analysis.

Strong points are the observations of the evaluator and his understanding of the concepts underlying the design and construction of the kits. His conclusions regarding possible redundancy of individual linear measurement kits at the expense of other kits dealing with other aspects of metric measurement seem especially cogent and relevant to me. Specific comments regarding use of blueprints and revisions of certain materials also appear legitimate. The analysis of the flexible sequencing of the kits after the initial slide/tape although subjective, appears reasonable and it is useful to know in terms of future applications.

Overall, the report conveys a note of encouragement. The evaluator clearly sees the value of such instructional materials for the designated population but a more systematic tryout would enable the developers to make further changes with greater confidence.

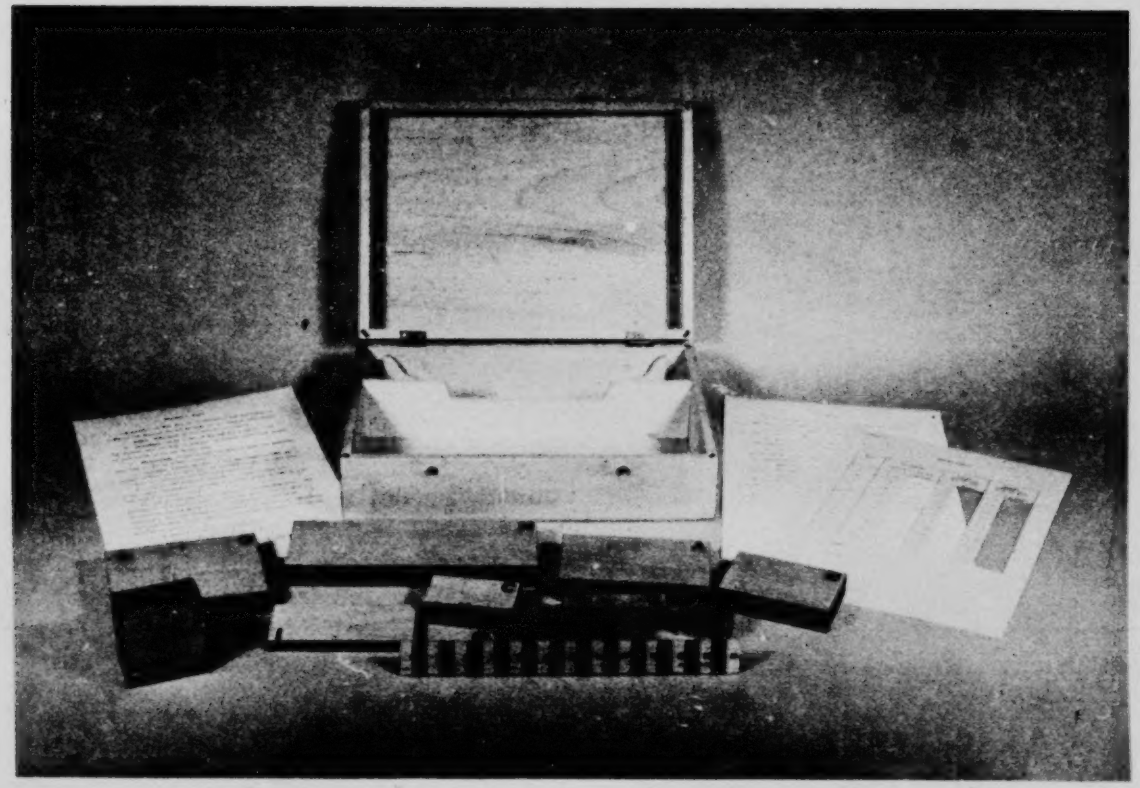
Sincerely yours,

Hilton

Hilton M. Bialek, PhD
Senior Staff Scientist

HMB:knb

Basic Kit



34

35

TEACHER'S GUIDE

The purpose of this kit is to determine how successfully students can measure blocks of wood to the closest centimetre.

A. Topic Measuring to the closest centimetre

B. Procedure Given a set of blocks and a metric rule, the student will be able to measure thickness, width and length of each block using the metric rule

C. Performance Students must be able to make the measurement and record on a tally sheet

D. Criteria Ninety percent of the measurements must be correct before the student will be allowed to use the next kit.

This kit contains the following material:

A. Ten blocks marked A through J. These blocks are color coded--thickness is yellow to yellow, width is red to red, and length is blue to blue.

B. One 25 centimetre rule marked in centimetres only. The centimetre is a fairly large unit in the metric system as 2.5 centimetres equals about 1 inch. Therefore, it should be relatively easy for students to measure to the closest centimetre. The rule is also color coded with alternate centimetre divisions painted in green.

C. A pencil to record the information.

D. A Record Sheet on which the student will record the measurements.

E. An Answer Card that can be placed over the Record Sheet for use in checking the correct answers.

PROCEDURES

1. Place the kit in front of the student and have him open the kit and remove the Record Sheet.

2. Have the student pick up the centimetre rule from the case.

3. Ask the student to place the blocks in front of him from left to right from A through J.

4. Ask him to use the rule and measure the thickness of block A from yellow to yellow, and record this measurement on the Record Sheet.

5. Next have him measure the width, from red to red, and record this measurement.

6. Have him measure the length, from blue to blue, and record this measurement. Continue this procedure for each of the other 9 blocks.

7. With the student observing, place the Answer Card over the Record Sheet and check each measurement. There will be 30 measurements in this assignment. Students must have 27 of these correct before proceeding to the next kit.

RECORD SHEET

PART	THICKNESS Yellow to Yellow	WIDTH INSIDE DIA. Red to Red	LENGTH OUTSIDE DIA. Blue to Blue
	Answer	Answer	Answer
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			

NAME

LOCATION

centimetre

RECORD SHEET

PART	THICKNESS Yellow to Yellow		WIDTH INSIDE DIA. Red to Red		LENGTH OUTSIDE DIA. Blue to Blue	
		Answer		Answer		Answer
A	2 cm		7 cm		12 cm	
B	2 cm		6 cm		9 cm	
C	2 cm		4 cm		7 cm	
D	2 cm		2 cm		4 cm	
E	2 cm		2 cm		8 cm	
F	2 cm		4 cm		10 cm	
G	2 cm		9 cm		12 cm	
H	2 cm		7 cm		20 cm	
I	1 cm		5 cm		11 cm	
J	4 cm		6 cm		6 cm	

NAME

LOCATION

RECORD SHEET

PART	THICKNESS Yellow to Yellow	WIDTH INSIDE DIA. Red to Red	LENGTH OUTSIDE DIA. Blue to Blue
	Answer	Answer	Answer
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			

NAME

LOCATION

centimetre

RECORD SHEET

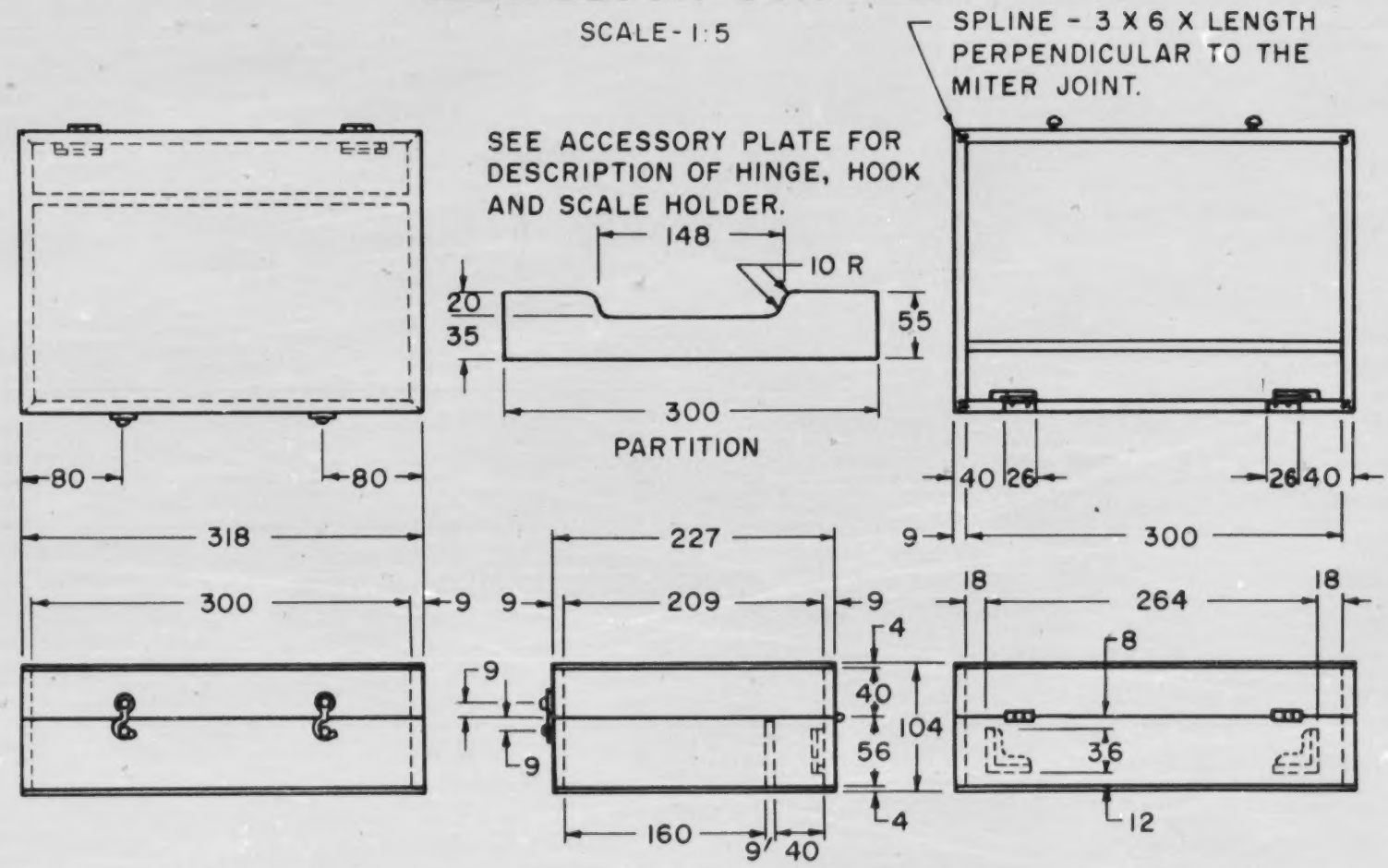
PART	THICKNESS Yellow to Yellow		WIDTH INSIDE DIA. Red to Red		LENGTH OUTSIDE DIA. Blue to Blue	
		Answer		Answer		Answer
A	3 cm		5 cm		9 cm	
B	2 cm		4 cm		6 cm	
C	1 cm		2 cm		6 cm	
D	1 cm		3 cm		10 cm	
E	1 cm		5 cm		11 cm	
F	2 cm		9 cm		12 cm	
G	2 cm		7 cm		20 cm	
H	2 cm		5 cm		8 cm	
I	4 cm		6 cm		6 cm	
J	2 cm		4 cm		10 cm	

NAME

LOCATION

BLOCK BOX

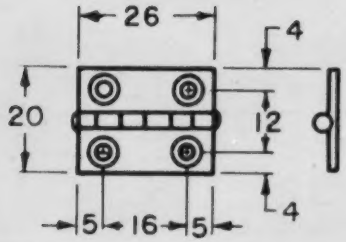
SCALE - 1:5



42

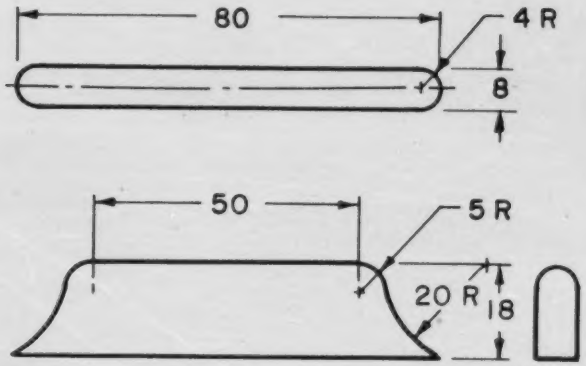
43

BOX ACCESSORIES



HINGE

HOOK



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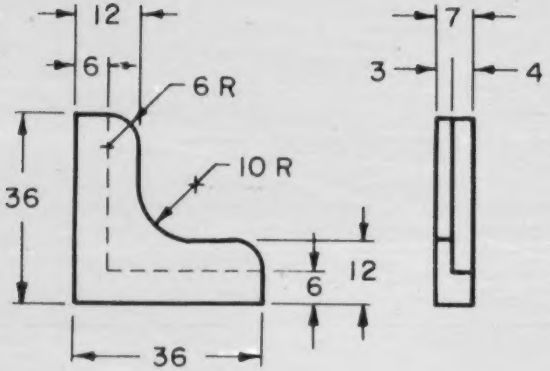
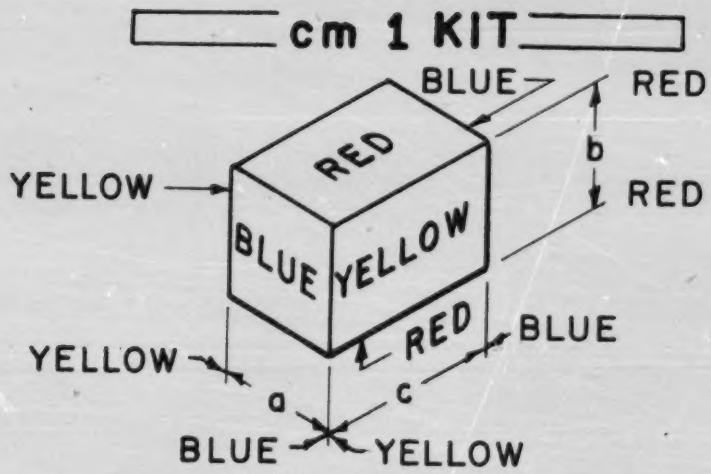


SCALE HOLDER
(ONE END)

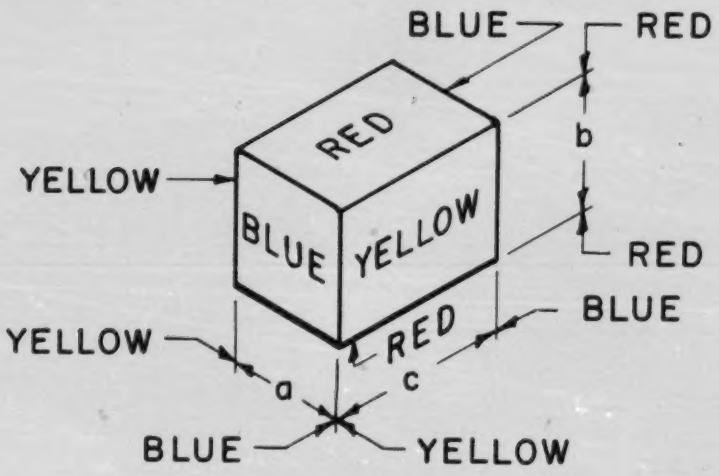
41

45



BLOCK	THICKNESS YELLOW TO YELLOW a	WIDTH INSIDE DIA RED TO RED b	LENGTH OUTSIDE DIA BLUE TO BLUE c
A	2.0	7.0	12.0
B	2.0	6.0	9.0
C	2.0	4.0	7.0
D	2.0	2.0	4.0
E	2.0	2.0	8.0
F	2.0	4.0	10.0
G	2.0	9.0	12.0
H	2.0	7.0	20.0
I	1.0	5.0	11.0
J	4.0	6.0	6.0

cm 2 KIT



BLOCK	THICKNESS YELLOW TO YELLOW a	WIDTH INSIDE DIA RED TO RED b	LENGTH OUTSIDE DIA BLUE TO BLUE c
A	2.5	5.0	9.0
B	2.0	4.0	6.0
C	1.0	2.0	6.0
D	1.0	3.0	10.0
E	1.0	5.0	11.0
F	2.0	9.0	12.0
G	2.0	7.0	20.0
H	2.0	5.0	8.0
I	4.0	6.0	6.0
J	2.0	4.0	10.0

TEACHER'S GUIDE

The purpose of this kit is to determine how successfully students can measure blocks of wood to the closest millimetre.

A. Topic Measuring to the closest millimetre

B. Procedure Given a set of blocks and a metric rule, the student will be able to measure thickness, width and length of each block using the metric rule

C. Performance Students must be able to make the measurement and record on a tally sheet

D. Criteria Ninety percent of the measurements must be correct before the student will be allowed to use the next kit.

This kit contains the following material:

A. Ten blocks marked A through J. These blocks are color coded--thickness is yellow to yellow, width is red to red, and length is blue to blue.

B. One 150 millimetre rule marked in millimetres. The millimetre is the smallest metric unit which the student will be working with.

C. A pencil to record the information.

D. A Record Sheet on which the student will record the measurements.

E. An Answer Card that can be placed over the Record Sheet for use in checking the correct answers.

PROCEDURES

1. Place the kit in front of the student and have him open the kit and remove the Record Sheet.

2. Have the student pick up the millimetre rule from the case.

3. Ask the student to place the blocks in front of him from left to right from A through J.

4. Ask him to use the rule and measure the thickness of block A from yellow to yellow, and record this measurement on the Record Sheet.

5. Next have him measure the width, from red to red, and record this measurement.

6. Have him measure the length, from blue to blue, and record this measurement. Continue this procedure for each of the other 9 blocks.

7. With the student observing, place the Answer Card over the Record Sheet and check each measurement. There will be 30 measurements in this assignment. Students must have 27 of these correct before proceeding to the next kit.

RECORD SHEET

PART	THICKNESS Yellow to Yellow	WIDTH INSIDE DIA. Red to Red	LENGTH OUTSIDE DIA. Blue to Blue
	Answer	Answer	Answer
A			
B			
C			
D			
E			
F			
G			
H			
I			
J			

NAME

LOCATION

millimetre

RECORD SHEET

PART	THICKNESS Yellow to Yellow		WIDTH INSIDE DIA. Red to Red		LENGTH OUTSIDE DIA. Blue to Blue	
		Answer		Answer		Answer
A	22 mm		39 mm		52 mm	
B	39 mm		61 mm		92 mm	
C	28 mm		29 mm		67 mm	
D	39 mm		17 mm		126 mm	
E	22 mm		124 mm		147 mm	
F	45 mm		51 mm		139 mm	
G	36 mm		17 mm		75 mm	
H	43 mm		51 mm		27 mm	
I	29 mm		26 mm		53 mm	
J	16 mm		33 mm		27 mm	

NAME

LOCATION

RECORD SHEET

PART	THICKNESS Yellow to Yellow		WIDTH INSIDE DIA. Red to Red		LENGTH OUTSIDE DIA. Blue to Blue	
		Answer		Answer		Answer
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						

NAME

LOCATION

millimetre

..

RECORD SHEET

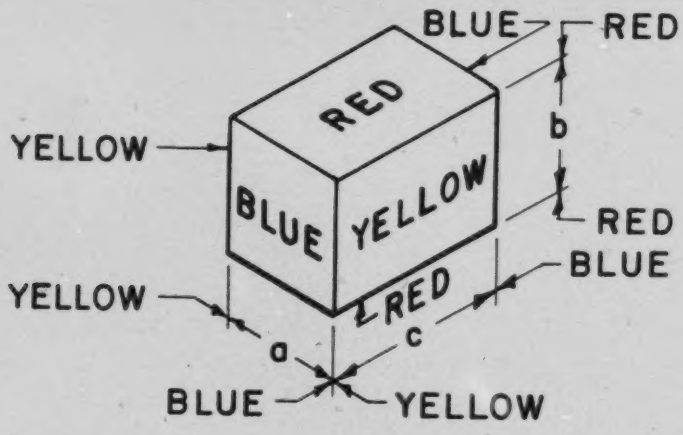
PART	THICKNESS Yellow to Yellow	Answer	WIDTH INSIDE DIA. Red to Red	Answer	LENGTH OUTSIDE DIA. Blue to Blue	Answer
A	22 mm		39 mm		52 mm	
B	39 mm		61 mm		92 mm	
C	28 mm		29 mm		67 mm	
D	39 mm		17 mm		126 mm	
E	22 mm		124 mm		147 mm	
F	45 mm		51 mm		139 mm	
G	22 mm		65 mm		73 mm	
H	22 mm		62 mm		64 mm	
I	39 mm		56 mm		59 mm	
J	49 mm		39 mm		69 mm	

NAME

53

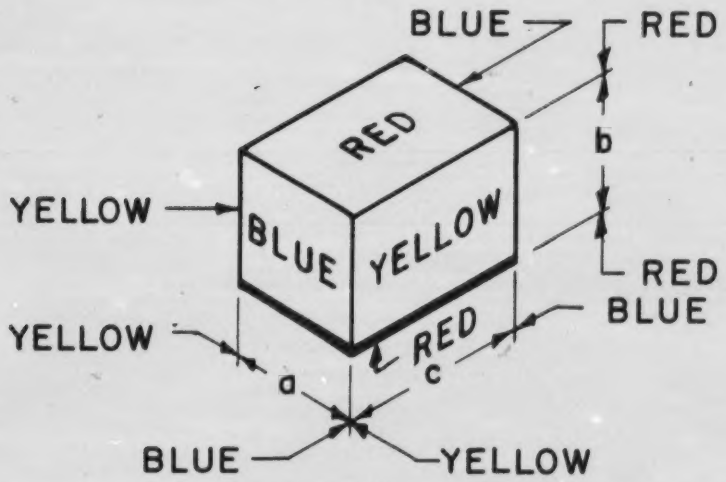
LOCATION

mm 1 KIT



BLOCK	THICKNESS YELLOW TO YELLOW a	WIDTH INSIDE DIA RED TO RED b	LENGTH OUTSIDE DIA BLUE TO BLUE c
A	22	39	52
B	39	61	92
C	28	29	67
D	39	17	126
E	22	124	147
F	45	51	139
G	36	17	75
H	43	51	27
I	29	26	53
J	17	33.	27

mm 2 KIT



BLOCK	THICKNESS YELLOW TO YELLOW a	WIDTH INSIDE DIA RED TO RED b	LENGTH OUTSIDE DIA BLUE TO BLUE c
A	22	39	52
B	39	61	92
C	28	29	67
D	39	17	126
E	22	124	147
F	45	51	139
G	22	65	73
H	22	62	64
I	39	56	59
J	49	39	69

TEACHER'S GUIDE

The purpose of this kit is to determine how succesfully students can measure thickness, inside diameter and outside diameter of disks to the closest millimetre.

A. Topic Measuring to the closest millimetre

B. Procedure Given a set of disks and a metric vernier caliper, the student will be able to measure thickness, inside diameter and outside diameter of each disk using the metric vernier caliper

C. Performance Students must be able to make the measurement and record on a tally sheet

D. Criteria Ninety percent of the measurements must be correct before the student will be allowed to use the next kit.

This kit contains the following material:

A. Ten disks marked A through J. These disks are color coded--thickness is yellow to yellow, inside diameter is measured at the red area, and outside diameter is measured at the blue area.

B. One 120 millimetre vernier caliper.

C. A pencil to record the information.

D. A Record Sheet on which the student will record the measurements.

E. An Answer Card, that can be placed over the tally sheet for use in checking the correct answers.

PROCEDURES

1. Place the kit in front of the student and have him open the kit and remove the Record Sheet.

2. Have the student pick up the vernier caliper from the case.

3. Ask the student to place the disks in front of him from left to right from A through J.

4. Ask him to use the vernier caliper and measure the thickness of disk A from yellow to yellow, and record this measurement on the Record Sheet.

5. Next have him measure the inside diameter of disk A and record this measurement.

6. Have him measure the outside diameter, and record this measurement. Continue this procedure for each of the other 9 disks.

7. With the student observing, place the Answer Card over the Record Sheet and check each measurement. There will be 30 measurements in this assignment. Students must have 27 of these correct before proceeding to the next kit.

RECORD SHEET

PART	THICKNESS Yellow to Yellow		WIDTH INSIDE DIA. Red to Red		LENGTH OUTSIDE DIA. Blue to Blue	
		Answer		Answer		Answer
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						

NAME

LOCATION

Disks

RECORD SHEET

PART	THICKNESS Yellow to Yellow		WIDTH INSIDE DIA. Red to Red		LENGTH OUTSIDE DIA. Blue to Blue	
		Answer		Answer		Answer
A	10 mm		21 mm		70 mm	
B	10 mm		28 mm		100 mm	
C	10 mm		41 mm		80 mm	
D	10 mm		46 mm		119 mm	
E	5 mm		6 mm		49 mm	
F	5 mm		6 mm		55 mm	
G	5 mm		8 mm		60 mm	
H	5 mm		7 mm		44 mm	
I	10 mm		5 mm		33 mm	
J	5 mm		7 mm		39 mm	

NAME

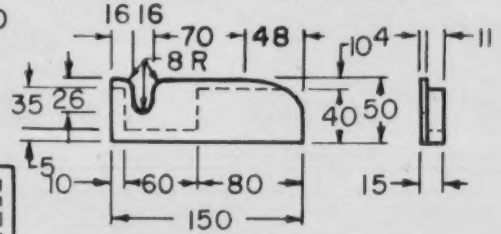
LOCATION

DISK BOX

PIN WASHER 1 - 28 DIA X 6
PIN WASHER 2 - 36 DIA X 6
HOLES TO FIT SNUGLY ONTO PINS.
PIN 1 - 6 DIA X 28
PIN 2 - 12.5 DIA X 48

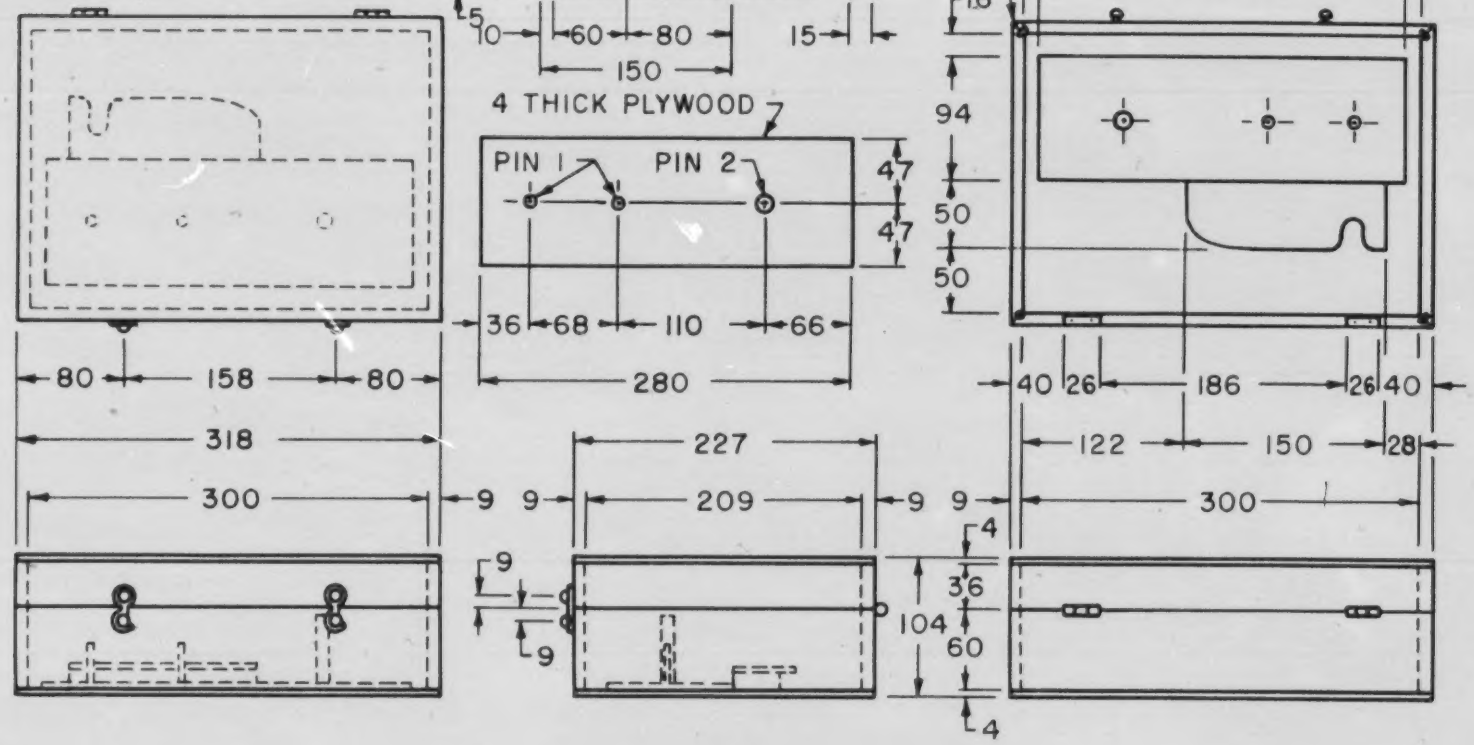
SCALE - 1 : 5

I.D.-O.D. MEASURE HOLDER

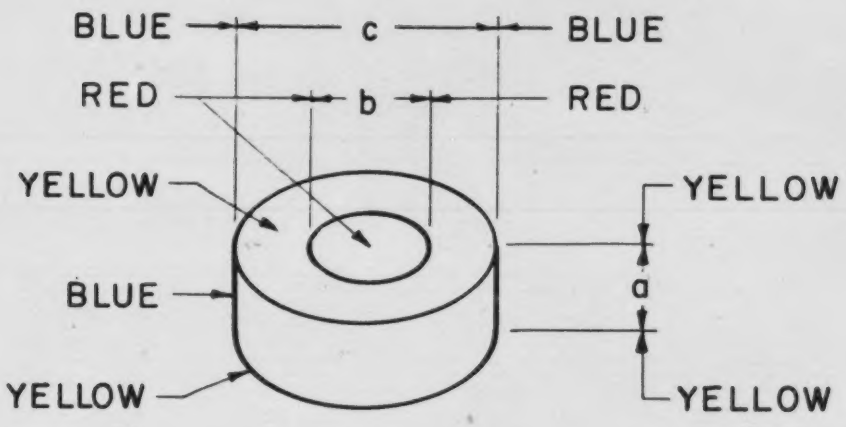


4 THICK PLYWOOD

SPLINE - 3 X 6 X LENGTH PERPENDICULAR TO THE MITER JOINT.



DISK KIT



DISK	THICKNESS YELLOW TO YELLOW a	WIDTH INSIDE DIA RED TO RED b	LENGTH OUTSIDE DIA BLUE TO BLUE c
A	10	21	70
B	10	28	100
C	10	41	80
D	10	46	119
E	5	6	49
F	5	6	55
G	5	8	60
H	5	7	44
I	10	6	33
J	5	7	39

TEACHER'S GUIDE

The purpose of this kit is to determine how succesfully the student can measure the lengths of common fasteners to the closest millimetre.

A. Topic Measuring fasteners to the closest millimetre

B. Procedure Given a set of fasteners and a metric vernier caliper, the student will be able to measure the length of each fastener to the closest millimetre

C. Performance Students must be able to make accurate measurements and record on a Record Sheet

D. Criteria Ninety percent of the measurements must be correct before the student will be allowed to use the next kit.

This kit contains the following material:

A. Fourteen fasteners marked A through N. These fasteners are color coded to fit the correct slots.

B. One 120 millimetre vernier caliper.

C. A pencil to record the information.

D. A Record Sheet on which the student will record the measurements.

E. An Answer Card that can be placed over the Record Sheet for use in checking the correct answers.

PROCEDURES

1. Place the kit in front of the student and have him open the kit and remove the Record Sheet.

2. Have the student remove the vernier caliper from the case.

3. Have the student remove fastener A from the case and measure the length. Record this measurement on the Record Sheet, and return fastener A to the box.

4. Remove fastener B from the case and measure the length. Record this measurement and proceed in the same manner until all fasteners have been measured and their lengths recorded on the Record Sheet.

5. With the student observing, place the Answer Card over the Record Sheet and check each measurement. There will be 14 measurements in this assignment. Students must have 12 of these correct before proceeding to the next kit.

RECORD SHEET

Fastener A _____ mm

Fastener B _____ mm

Fastener C _____ mm

Fastener D _____ mm

Fastener E _____ mm

Fastener F _____ mm

Fastener G _____ mm

Fastener H _____ mm

Fastener I _____ mm

Fastener J _____ mm

Fastener K _____ mm

Fastener L _____ mm

Fastener M _____ mm

Fastener N _____ mm

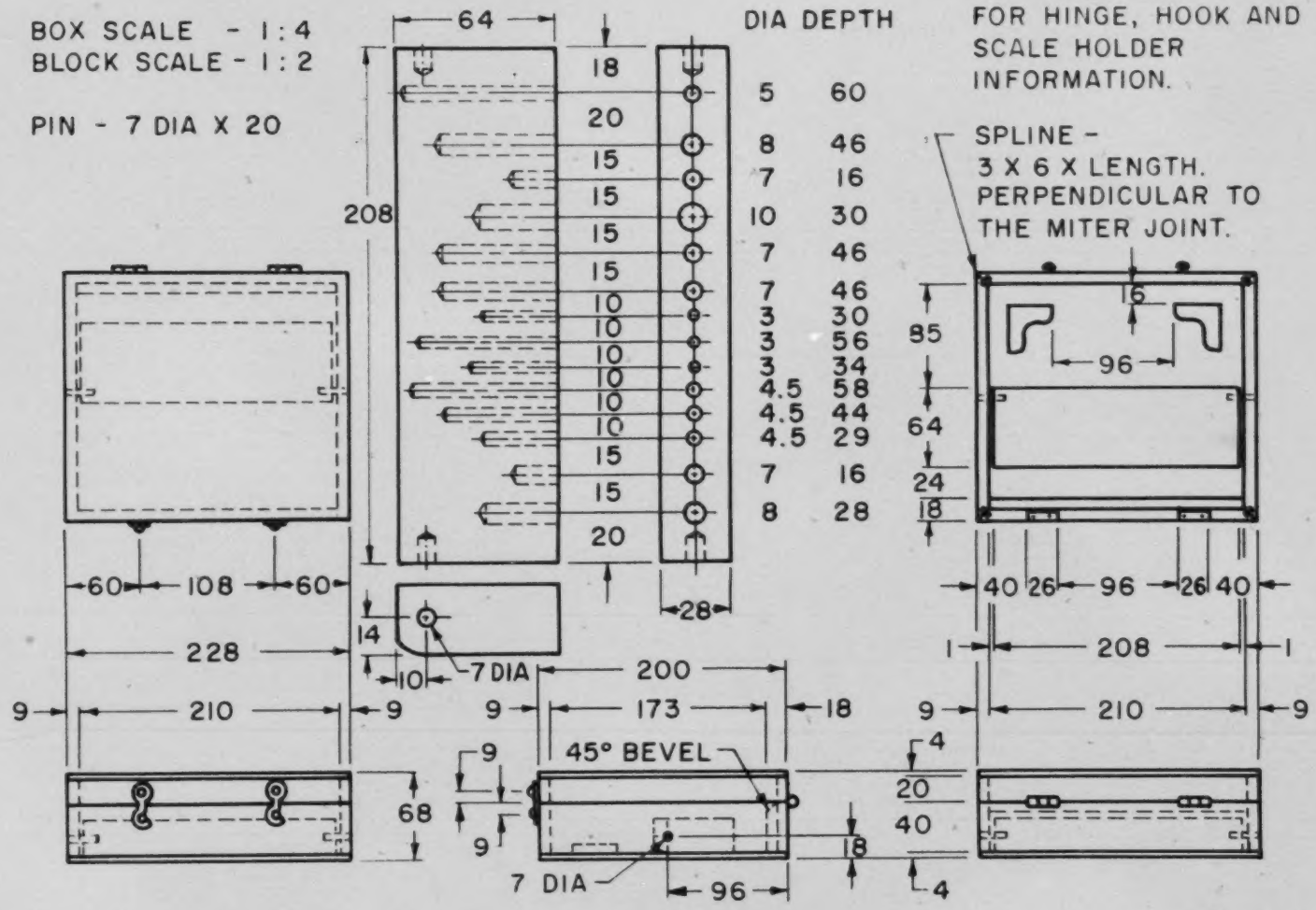
RECORD SHEET

	ANSWERS	
Fastener A	78	mm
Fastener B	56	mm
Fastener C	39	mm
Fastener D	51	mm
Fastener E	66	mm
Fastener F	62	mm
Fastener G	52	mm
Fastener H	77	mm
Fastener I	55	mm
Fastener J	78	mm
Fastener K	66	mm
Fastener L	50	mm
Fastener M	38	mm
Fastener N	51	mm

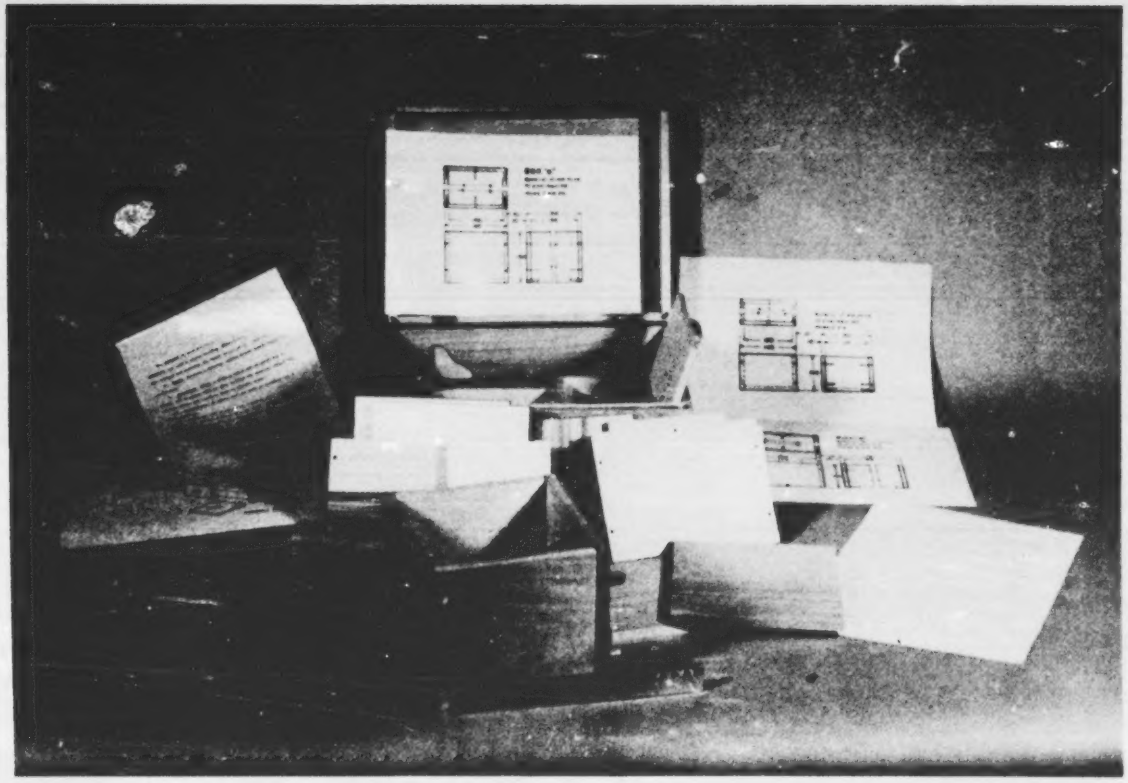
BOLT AND NAIL BOX

BOX SCALE - 1:4
BLOCK SCALE - 1:2

PIN - 7 DIA X 20



Advanced Kit



69

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TEACHER'S GUIDE

The purpose of this kit is to determine how succesfully students can read a metric drawing, measure and select parts for 3 boxes and assemble the boxes according to a drawing.

A. Topic Reading a drawing, making metric measurements and assembling

B. Procedure Given a drawing and a set of parts for 3 boxes, the students will be able to read the drawing, select the correct parts and assemble them in correct order

C. Performance Students must be able to assemble the 3 boxes properly

D. Criteria The student must complete this project without mistake. No incorrect parts must be used. If necessary, he must repeat the process until all are correct.

This kit contains the following:

A. Three drawings marked "A", "B", "C" for different boxes and an assembly drawing marked "D".

B. Seventeen parts for boxes, 15 of which are correct and 2 of which are rejects.

C. Thirty pins for assembling the boxes.

D. One 150 millimetre rule marked in millimetres.

PROCEDURES

1. Place the kit in front of the student and have him open the kit and remove the drawings. Place the 4 drawings (drawing A, B, C plus the assembly drawing) in front of him.

2. Ask the student to remove the 17 parts for the 3 boxes. Also, have him remove the pins for assembling the boxes. Ask the student to pick up the millimetre rule from the case.

3. Ask the student to study drawing A. Then measure the parts and select the 5 parts needed for box A. Place these 5 parts in 1 pile.

4. Ask the student to study drawing B. Then measure the parts and select the 5 parts needed for box B. Place these 5 parts in a separate pile.

5. Ask the student to study drawing C. Ask him to measure the parts and select the 5 parts needed for the box and stack them in a pile.

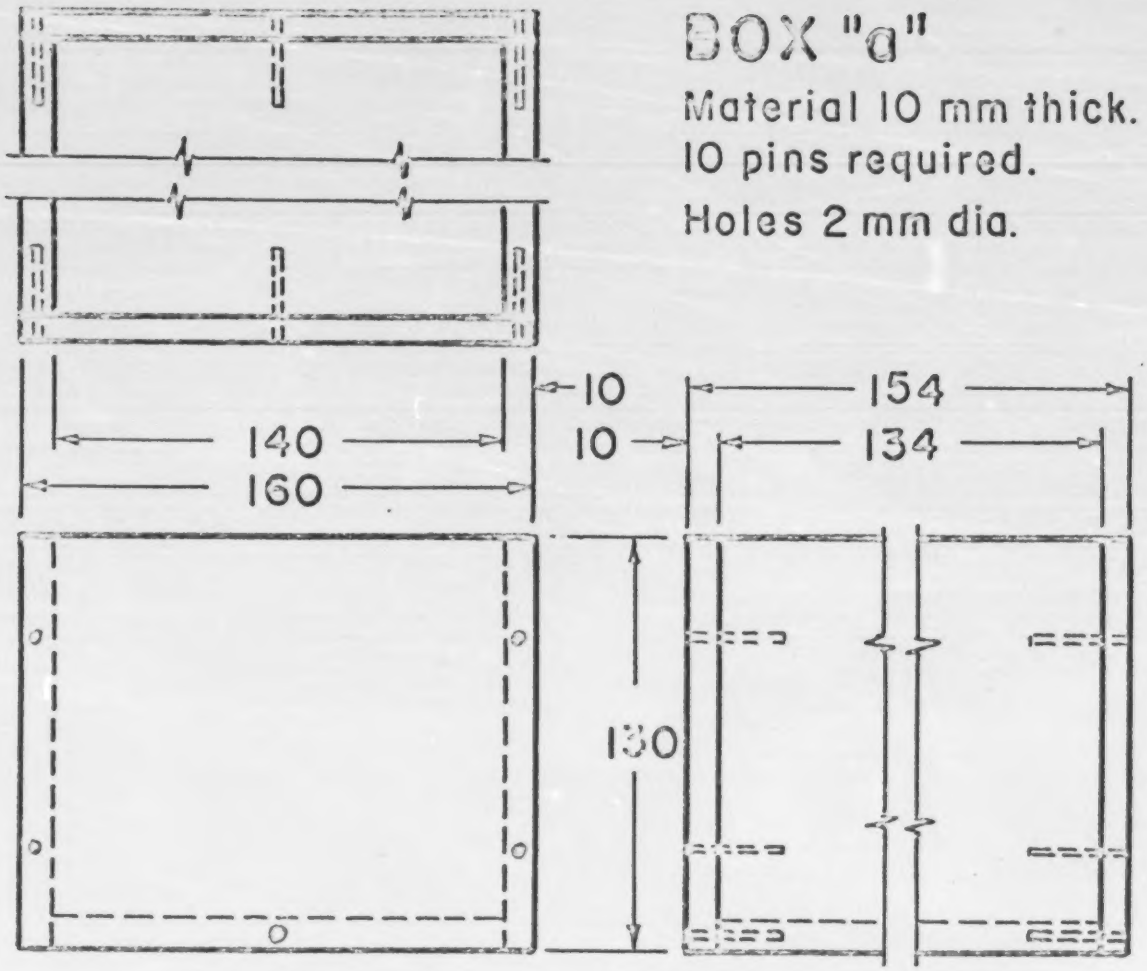
6. Return the 2 unused parts to the box.

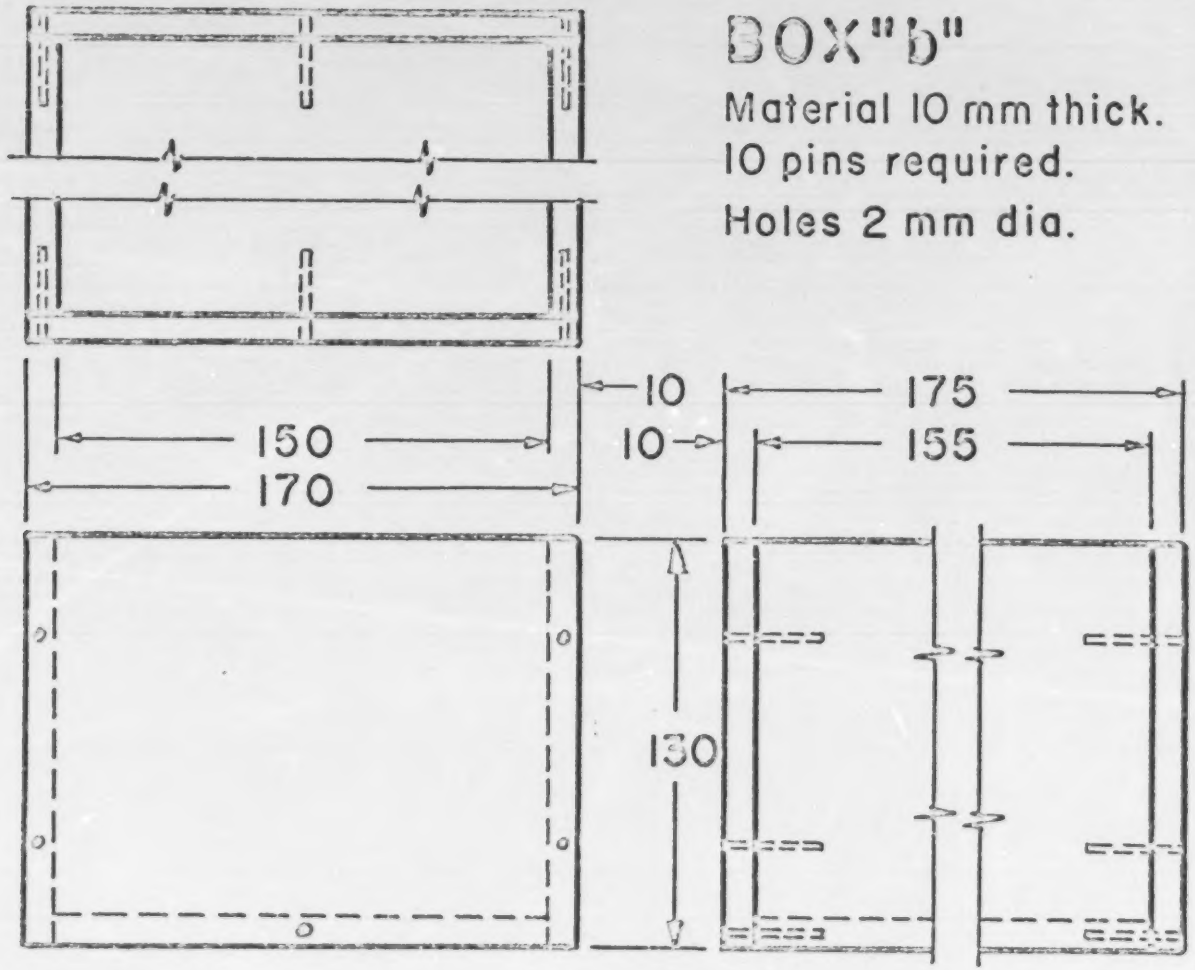
7. Ask the student to study the assembly drawing for the box. Then assemble box A using the pins to hold the parts together.

8. Repeat this process for box B.

9. Repeat this process for box C.

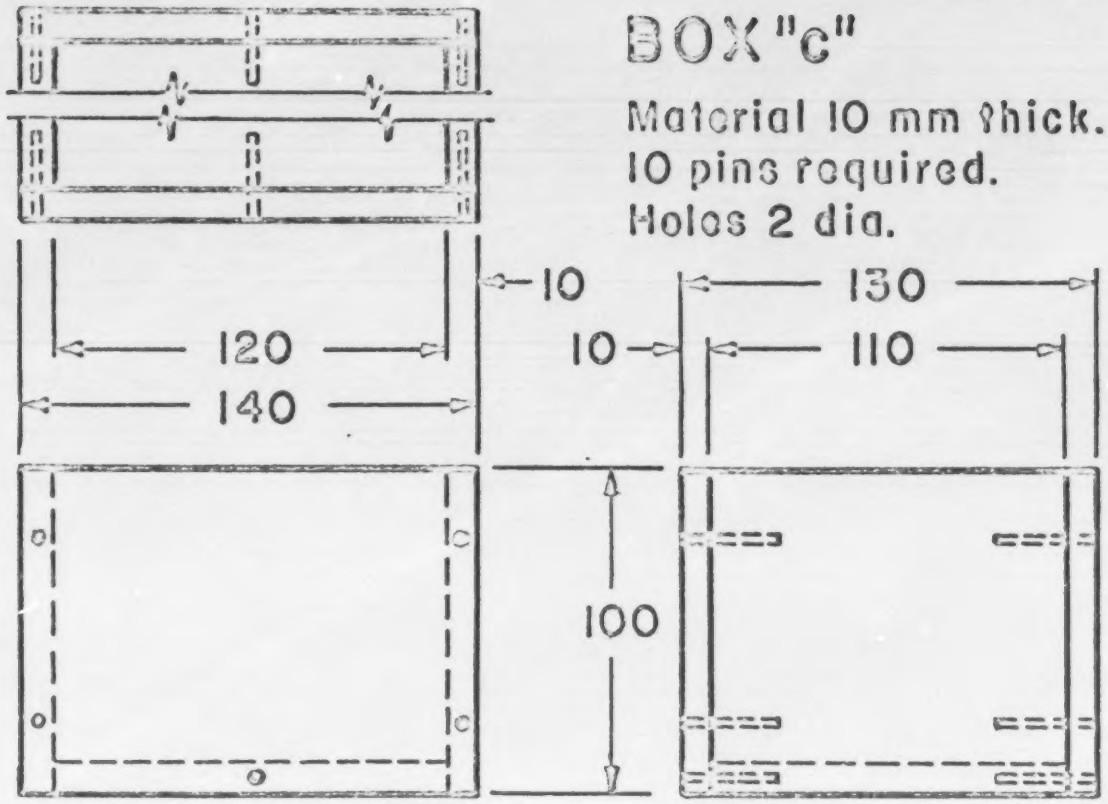
10. If the student cannot complete this assignment, have him repeat a measuring assignment for the millimetre blocks and then return to this activity.


BOX "a"
Material 10 mm thick.
10 pins required.
Holes 2 mm dia.
10
154
10
134
140
160
130


BOX "b"
Material 10 mm thick.
10 pins required.
Holes 2 mm dia.
10
175
10
155
150
170
130

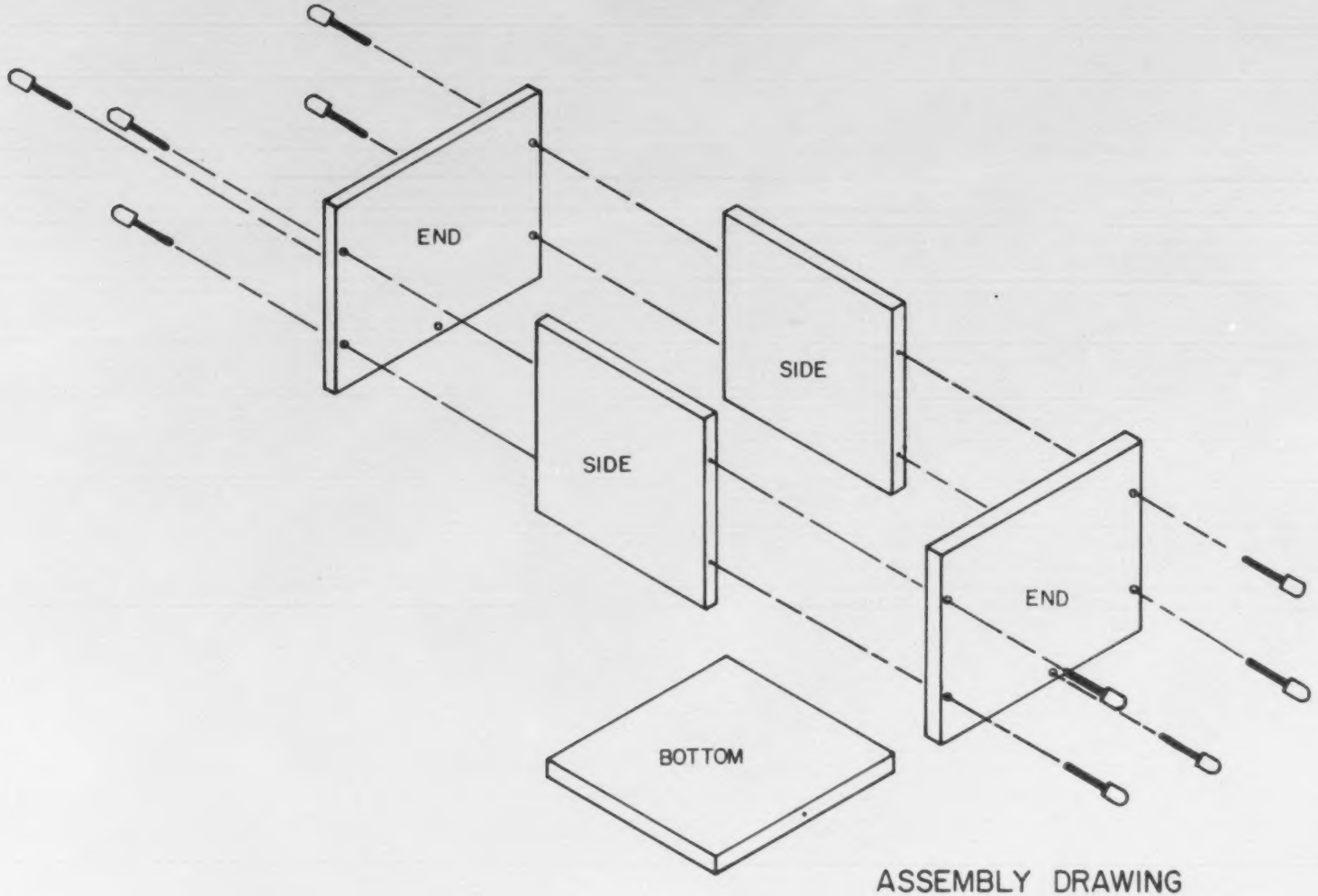
75

76


BOX "C"
Material 10 mm thick.
10 pins required.
Holes 2 dia.
10
130
120
10
110
140
100

77

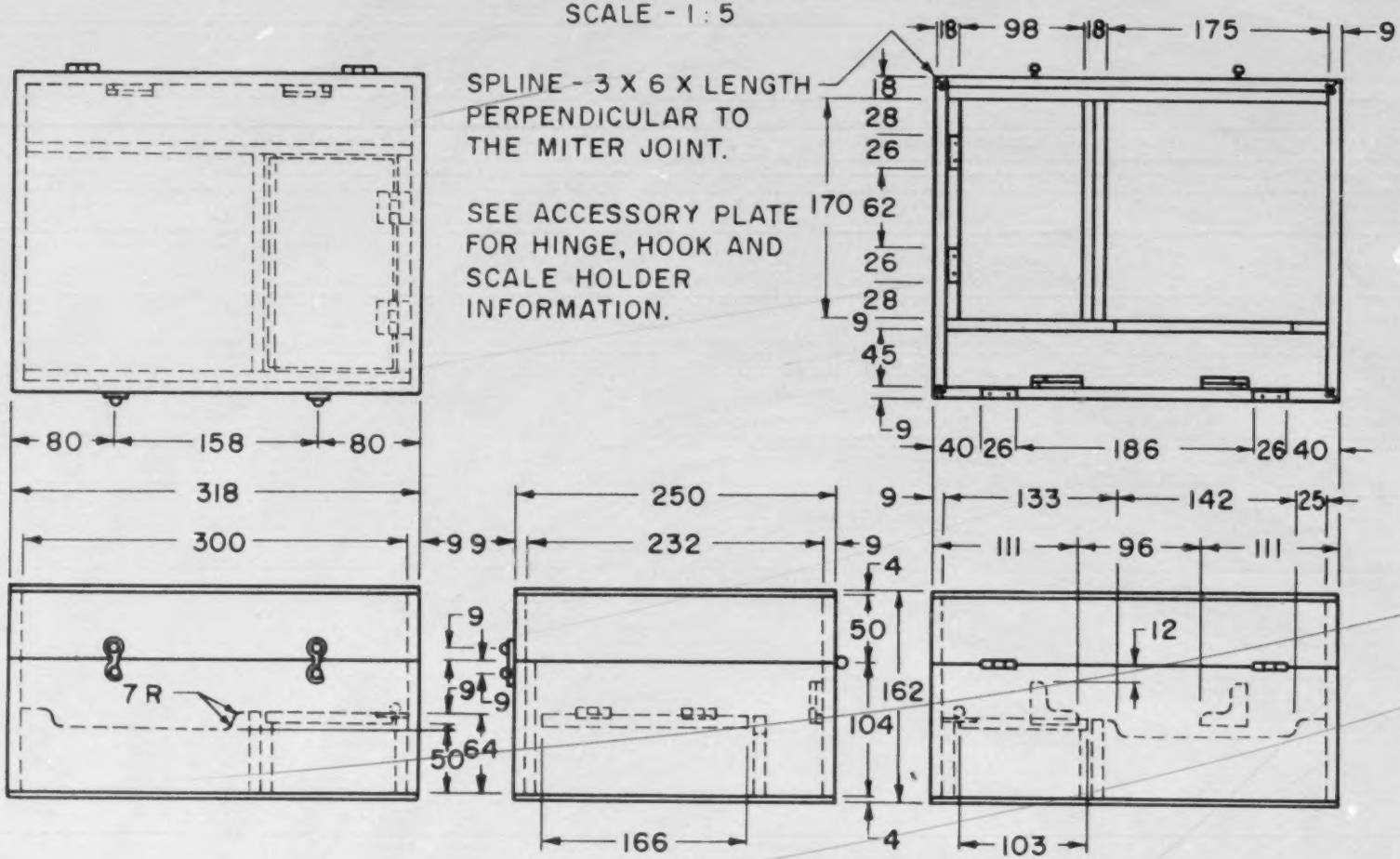
78



ASSEMBLY DRAWING

BOX FOR BOX PARTS

SCALE - 1 : 5



81

82

BOXES TO BE ASSEMBLED WITH 10 PINS

THE ASSEMBLED BOXES

OUTSIDE BOX DIMENSIONS

BOX	LENGTH	WIDTH	HEIGHT
a	160	154	130
b	170	175	130
c	140	130	100

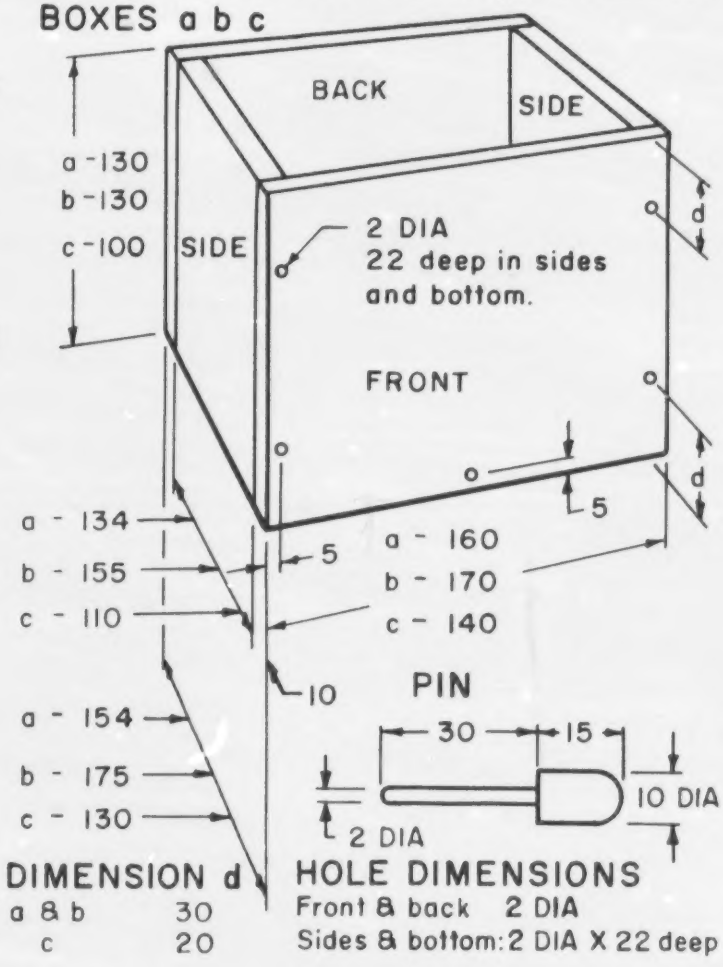
PIECE DIMENSIONS

BOX	THICK	WIDTH	LENGTH
a			
front*	10	130	160
side	10	130	134
bottom	10	134	140
b			
front*	10	130	170
side	10	130	155
bottom	10	155	150
c			
front*	10	100	140
side	10	100	110
bottom	10	110	120

EXTRA FRONT PIECES

1 pc	10	130	155
1 pc	10	100	150

* Front and back are alike.
Side pieces are alike.



DIMENSION d

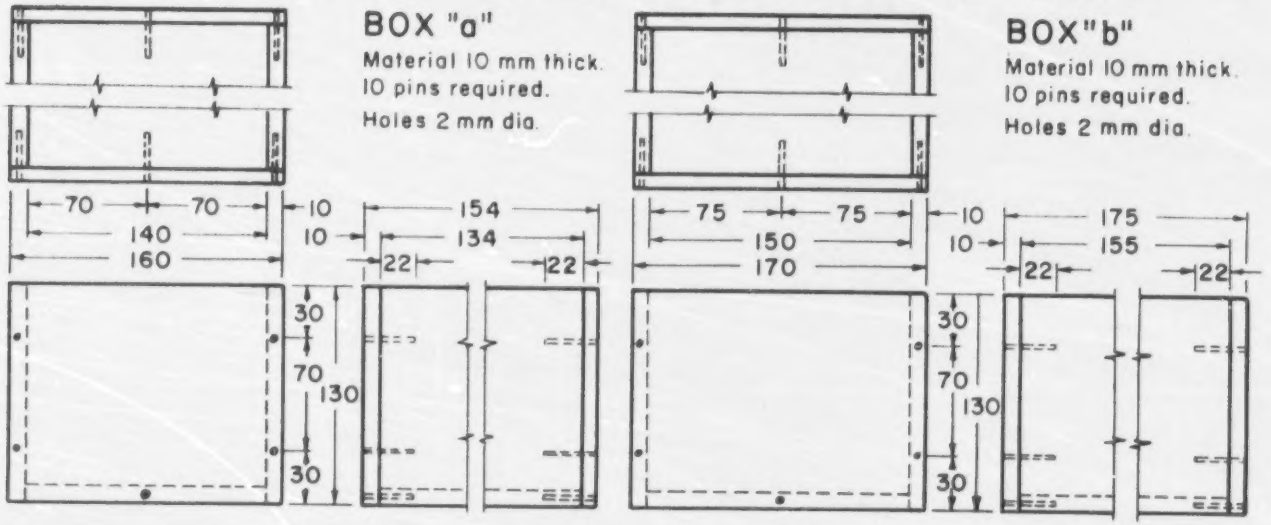
a & b	30
c	20

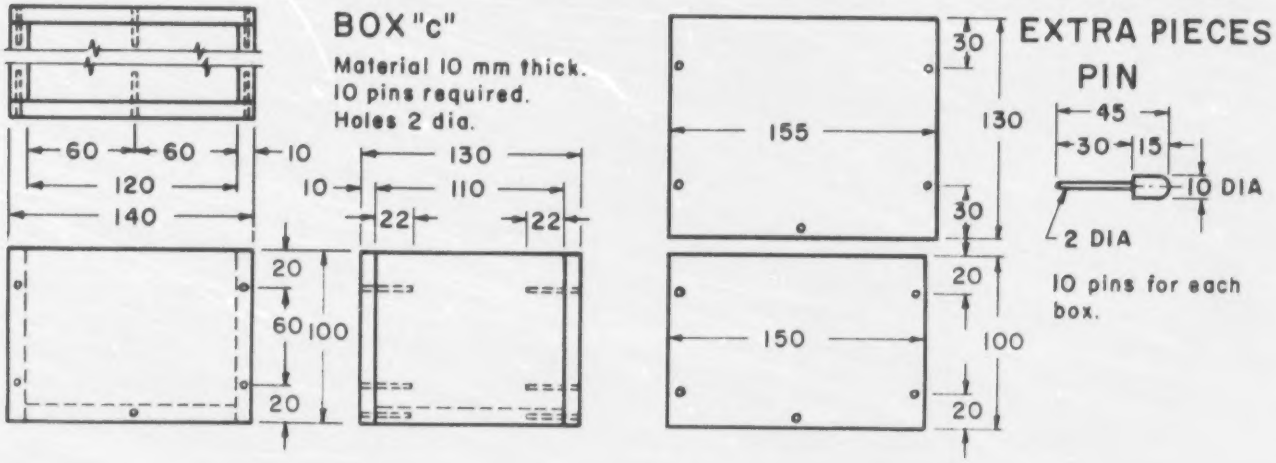
HOLE DIMENSIONS

Front & back 2 DIA

Sides & bottom: 2 DIA X 22 deep

BOXES TO BE ASSEMBLED WITH 10 PINS





ASSEMBLING A TOOLMAKER'S CLAMP

This kit contains the following material.

1. A metric drawing of a toolmaker's clamp--note all of the dimensions are in millimetres.

2. One 150 millimetre metric rule. The smallest division on this rule is one millimetre.

3. One thread gage.

4. Parts for 3 toolmaker's clamps. One complete set of these parts is correct; the other 8 parts are incorrect.

5. Using the 150 mm scale and following the dimensions on the drawing, select the 2 flat clamp parts that match the drawing itself.

6. With the metric thread gage, check the diameter and pitch of the correct thread. The ISO thread, as shown in the drawing, is M8 x 1.25.

7. After the 4 parts have been selected, assemble the clamp.

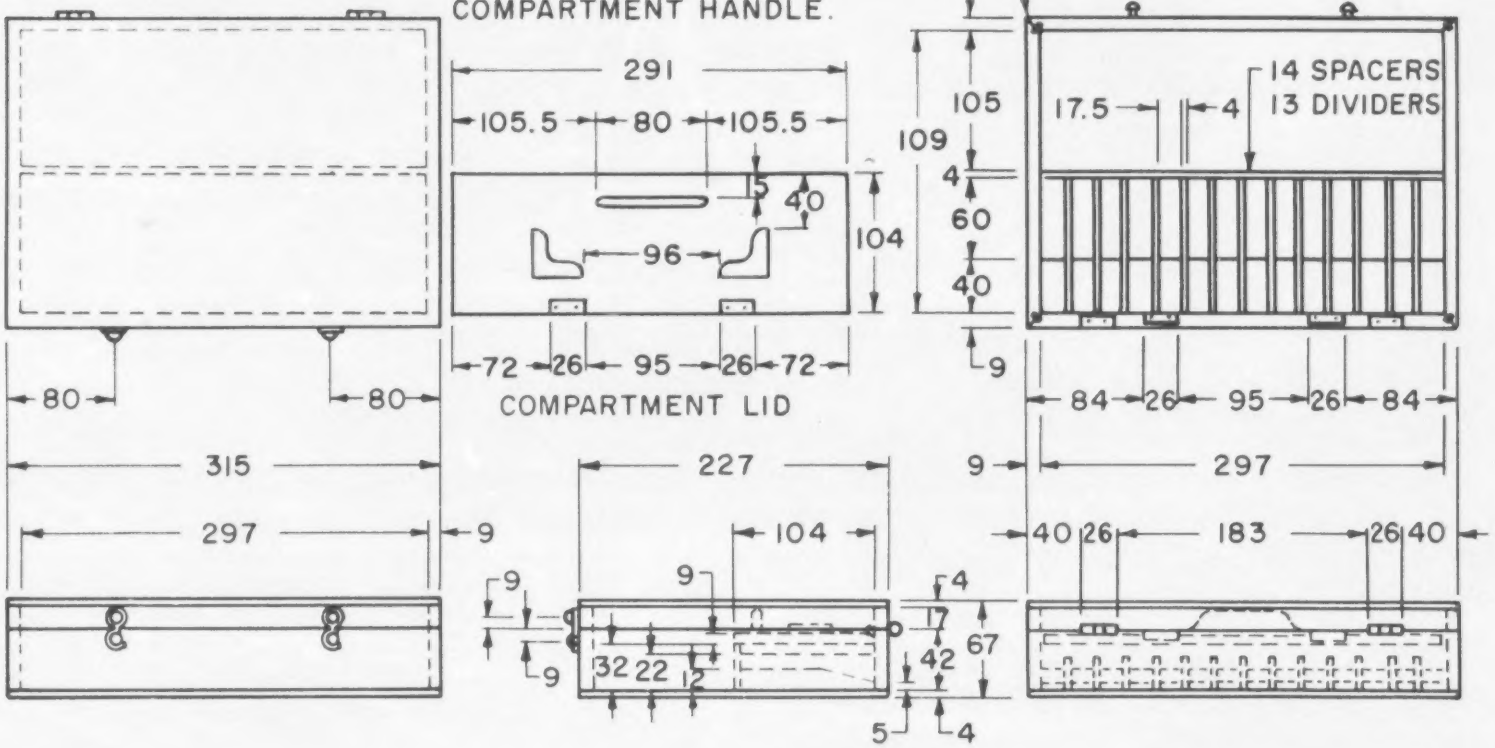
HARDWARE BOX

SCALE - 1 : 5

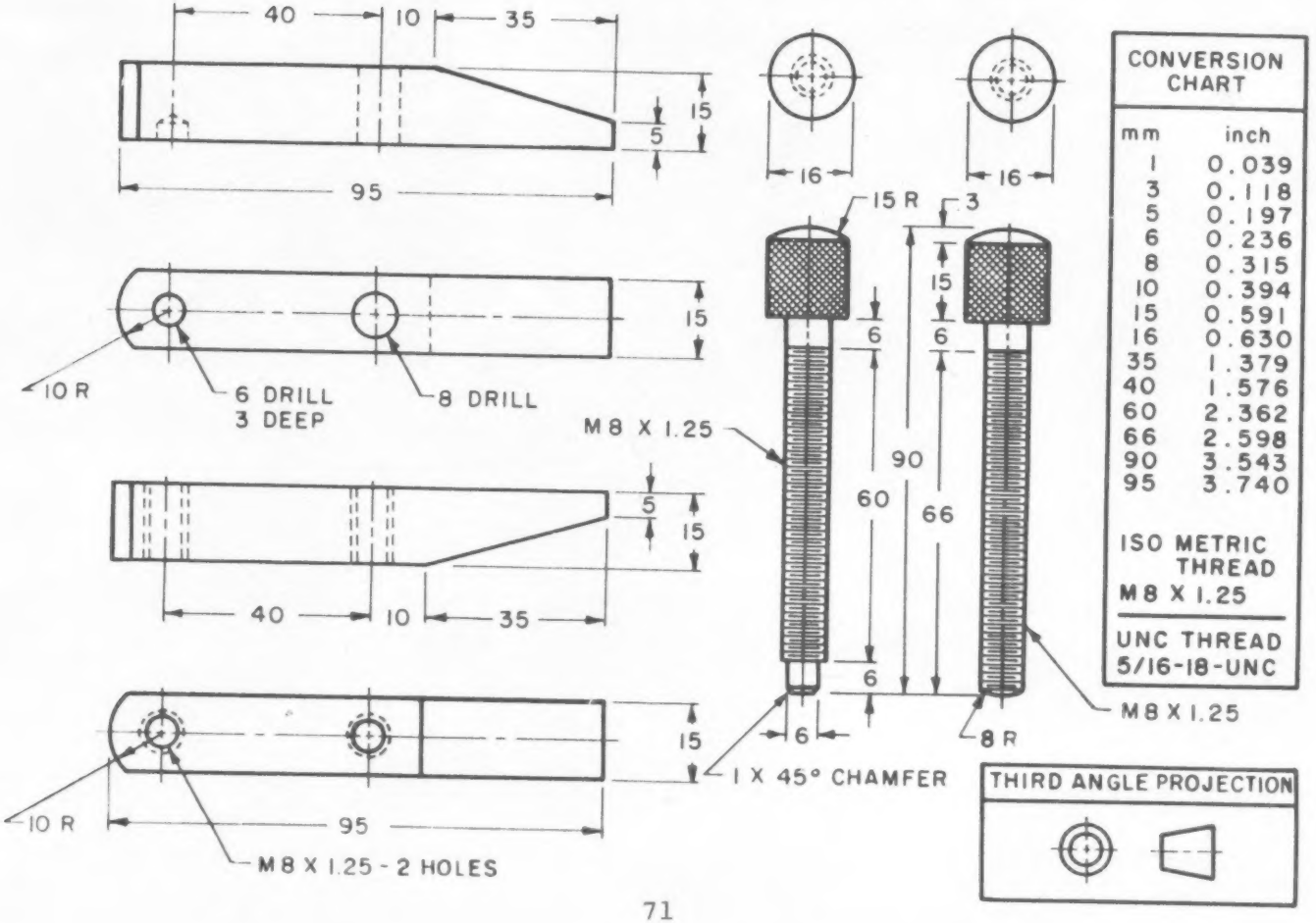
DIVIDER - 4 X 22 X 100
SPACER - 12 X 17.5 X 100
WITH TAPER AT REAR.

SEE ACCESSORY PLATE FOR THE DESCRIPTION OF HINGE, HOOK, SCALE HOLDER AND THE COMPARTMENT HANDLE.

SPLINE - 3 X 6 X LENGTH. PERPENDICULAR TO THE MITER JOINT.



METRIC DRAWING - METALWORKING
(TOOLMAKER'S CLAMP)

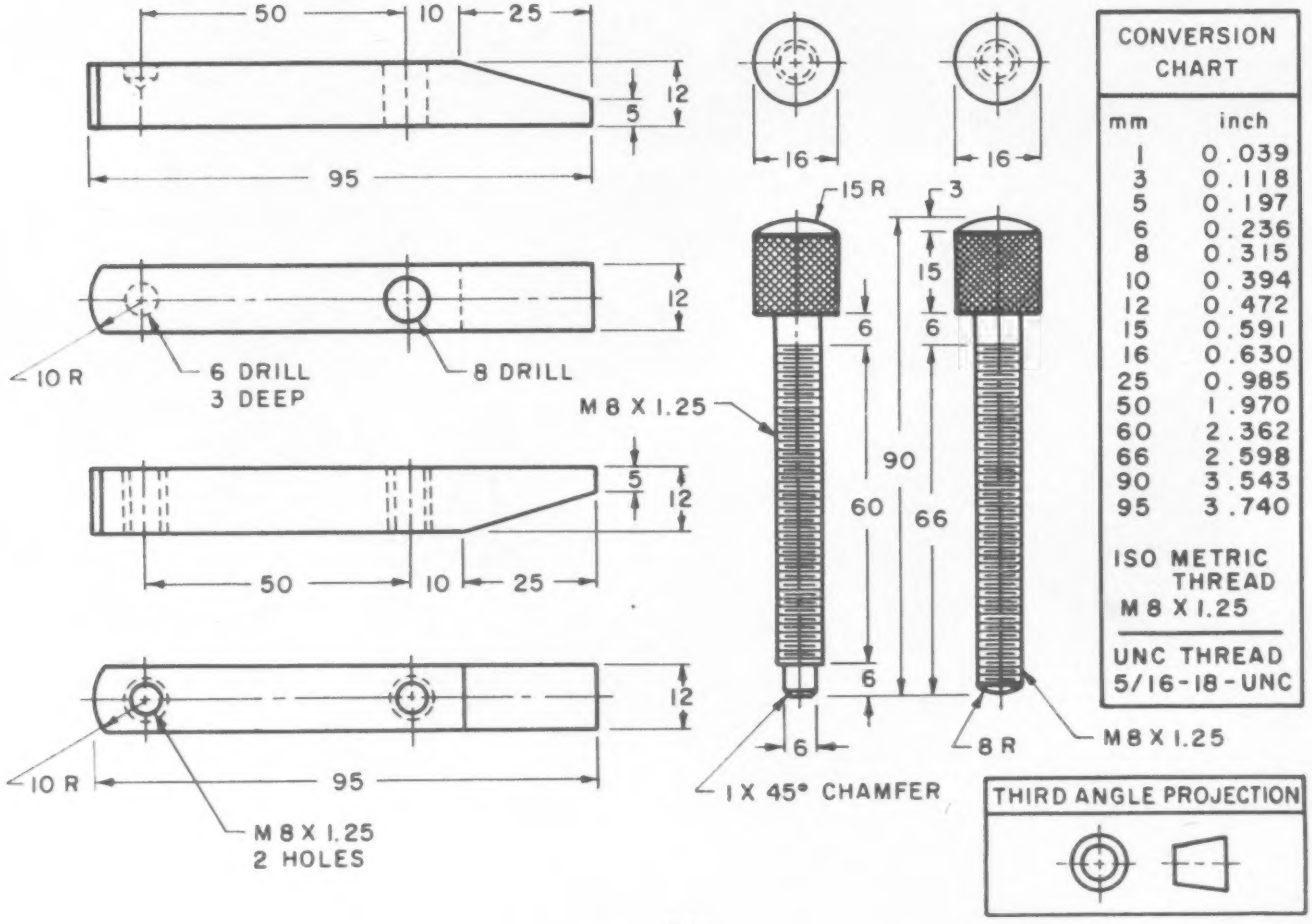


CONVERSION CHART	
mm	inch
1	0.039
3	0.118
5	0.197
6	0.236
8	0.315
10	0.394
15	0.591
16	0.630
35	1.379
40	1.576
60	2.362
66	2.598
90	3.543
95	3.740

ISO METRIC THREAD
M8 X 1.25

UNC THREAD
5/16-18-UNC

METRIC DRAWING - METALWORKING
(TOOLMAKER'S CLAMP)

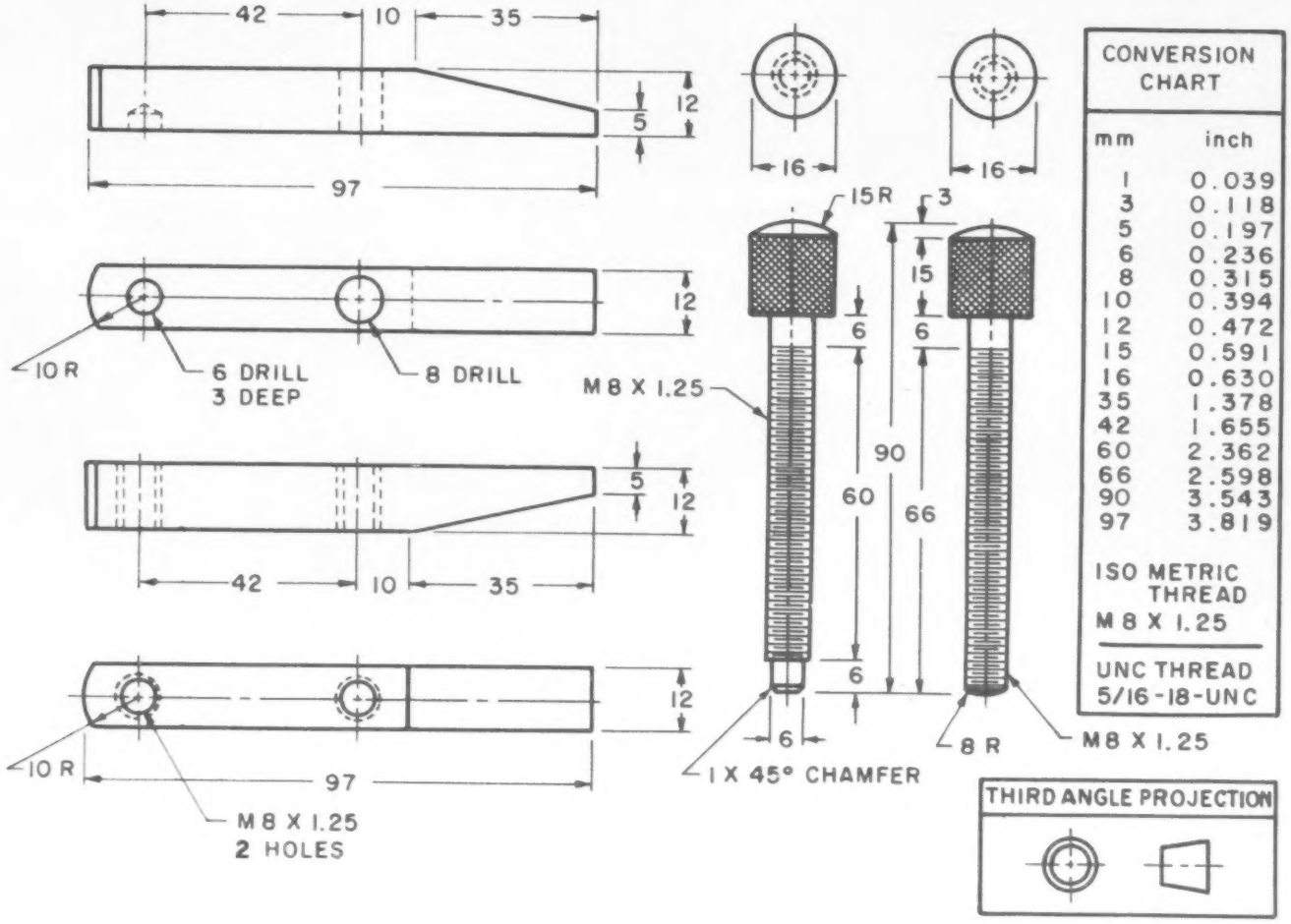


CONVERSION CHART	
mm	inch
1	0.039
3	0.118
5	0.197
6	0.236
8	0.315
10	0.394
12	0.472
15	0.591
16	0.630
25	0.985
50	1.970
60	2.362
66	2.598
90	3.543
95	3.740

ISO METRIC THREAD
M 8 X 1.25

UNC THREAD
5/16-18-UNC

METRIC DRAWING - METALWORKING
(TOOLMAKER'S CLAMP)



CONVERSION CHART	
mm	inch
1	0.039
3	0.118
5	0.197
6	0.236
8	0.315
10	0.394
12	0.472
15	0.591
16	0.630
35	1.378
42	1.655
60	2.362
66	2.598
90	3.543
97	3.819

ISO METRIC THREAD
M 8 X 1.25

UNC THREAD
5/16 - 18 - UNC

THIRD ANGLE PROJECTION

91

95

TEACHER'S GUIDE

The purpose of this kit is to determine how successfully students can weigh (determine mass) of common everyday items to the nearest gram (plus or minus 1 gram).

A. Topic Weighing (determining mass) of common items

B. Procedure Given a balance scale, a set of metric weights and common household items, the student will be able to determine the weight of each item to the nearest gram

C. Performance Students must be able to make the measurements and record on a Record Sheet

D. Criteria Ninety percent of the measurements must be correct before the student will be allowed to use another kit. Students must make measurements to an accuracy of plus or minus 1 gram.

This kit contains the following material:

A. A balance scale with a yellow container on one side and a red container on the other.

B. Plastic weight units of 1 gram, 5 grams, and 10 grams.

C. Common household items that are color coded for identification.

D. A pencil to record the information.

E. A Record Sheet.

F. An Answer Card that can be placed over the Record Sheet for use in checking the correct answers.

PROCEDURES

1. Place the kit in front of the student, and have him open the kit. Ask him to remove the balance scale and assemble it.

2. Have the student place the plastic weights to the left of the balance scale. Have the student place the common household items to the right.

3. Have the student remove the Record Sheet and pencil and place them in front of the balance scale.

4. Have the student select the first item on the Record Sheet by name and color code. Place this item in the red bin of the balance scale.

5. Select the right combination of weights and place them in the yellow bin until the balance scale is level.

6. Record the correct weight on the Answer Sheet.

7. Remove the weights from the yellow bin and stack them properly.

8. Remove the common household item from the red bin and return it to the kit.

9. Repeat this procedure for each item using the name and color code to identify the items.

WEIGHT

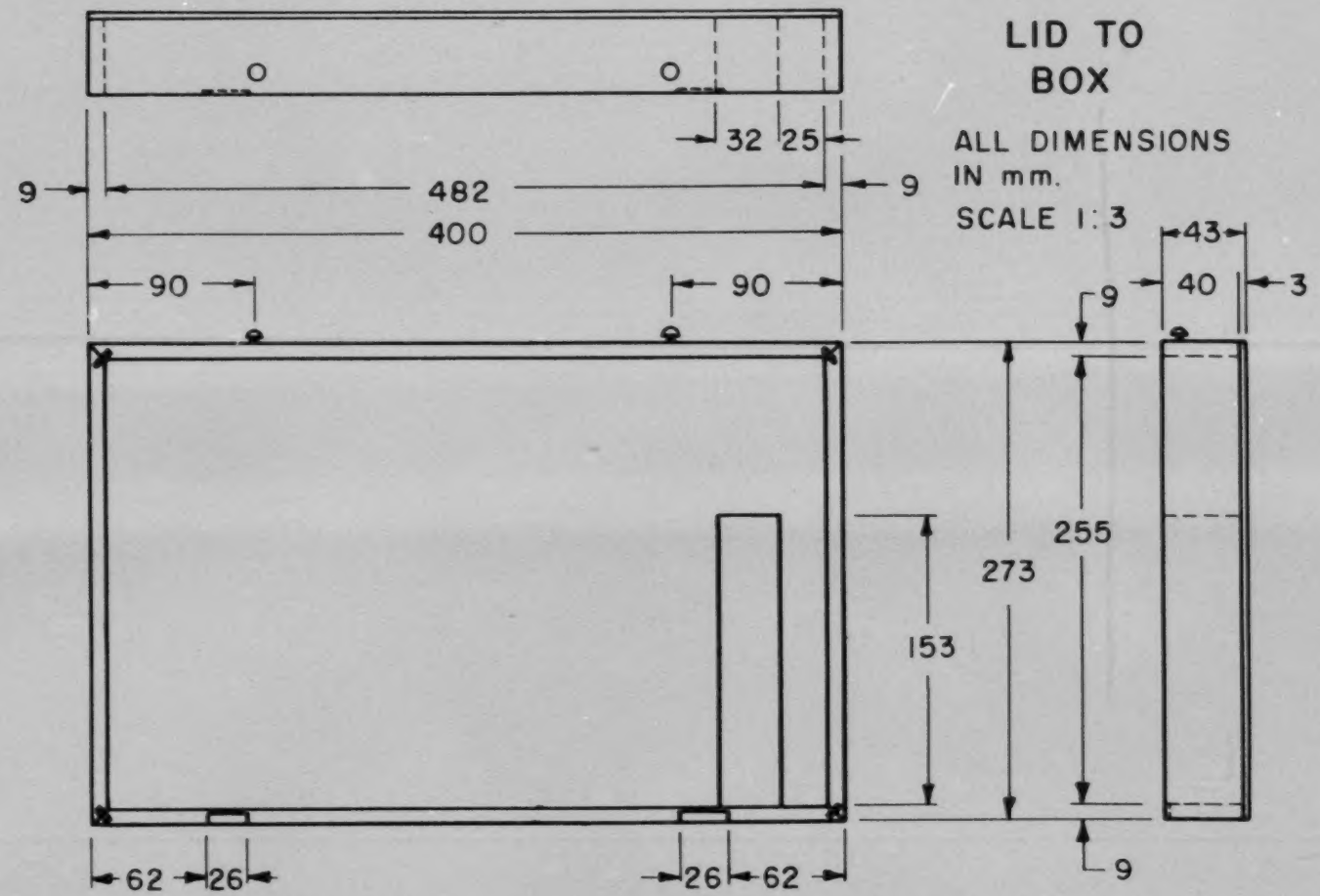
RECORD SHEET

ITEM	DESCRIPTION	COLOR CODE	WEIGHT
1	Nut & bolt combination	green	_____
2	Dowel	black	_____
3	Battery	double red	_____
4	Spool	double blue	_____
5	Flash cube	double orange	_____
6	Large nut	yellow	_____
7	Small hexhead nut	red	_____
8	Small nut	double yellow	_____
9	Nail	double white	_____
10	Carriage bolt	orange	_____
11	Flathead machine screw	blue	_____
12	Paper clip	double green	_____
13	Flathead screw	triple yellow	_____
14	Flathead screw	double black	_____
15	Lag screw	white	_____

RECORD SHEET

ITEM	DESCRIPTION	COLOR CODE	WEIGHT	ANSWERS
1	Nut & bolt combination	green	_____	76 g
2	Dowel	black	_____	4 g
3	Battery	double red	_____	47 g
4	Spool	double blue	_____	5 g
5	Flash cube	double orange	_____	11 g
6	Large nut	yellow	_____	28 g
7	Small hexhead nut	red	_____	5 g
8	Small nut	double yellow	_____	3 g
9	Nail	double white	_____	7 g
10	Carriage bolt	orange	_____	72 g
11	Flathead machine screw	blue	_____	14 g
12	Paper clip	double green	_____	2 g
13	Flathead screw	triple yellow	_____	8 g
14	Flathead screw	double black	_____	2 g
15	Lag screw	white	_____	17 g

STORAGE BOX FOR BALANCE



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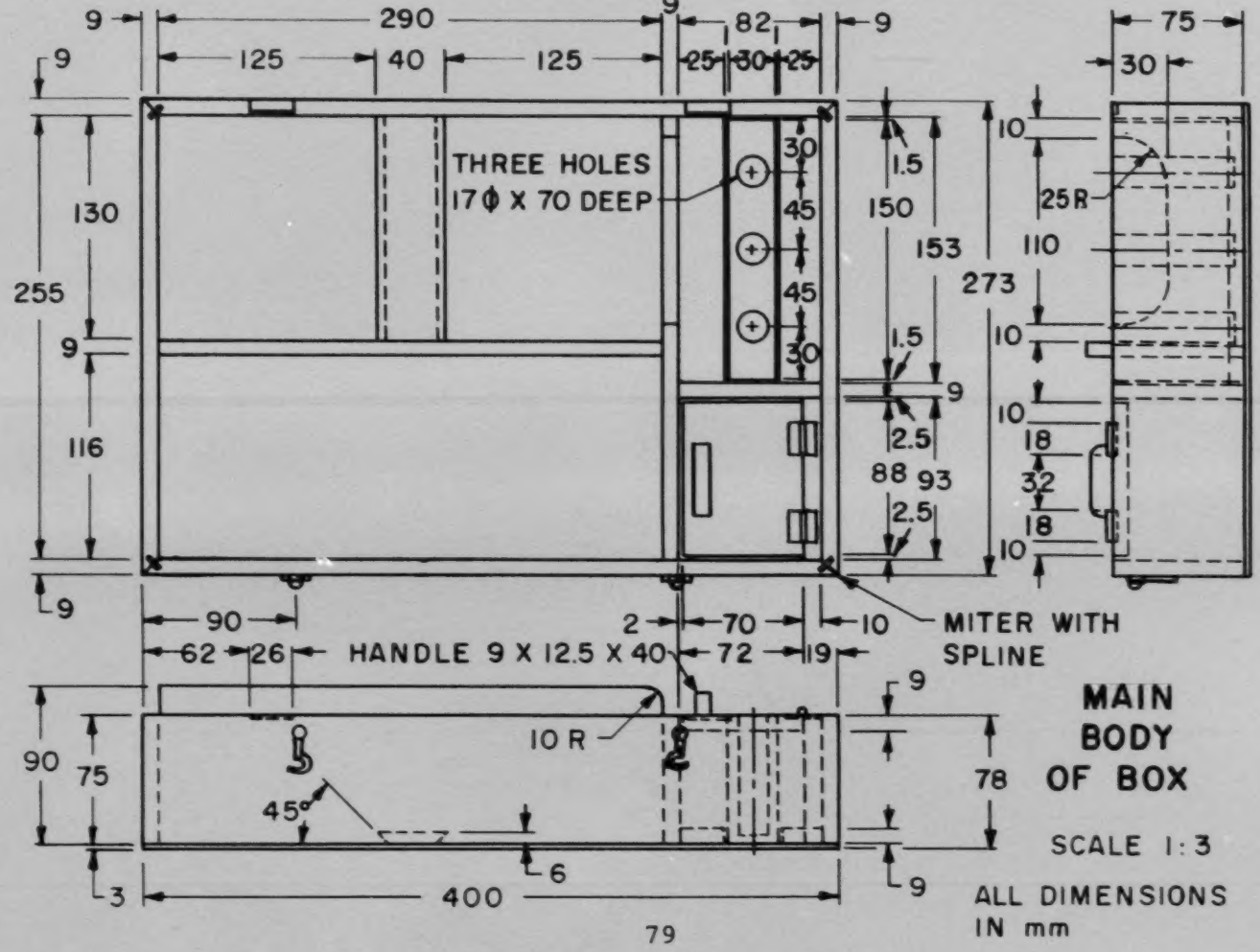
STORAGE BOX FOR BALANCE

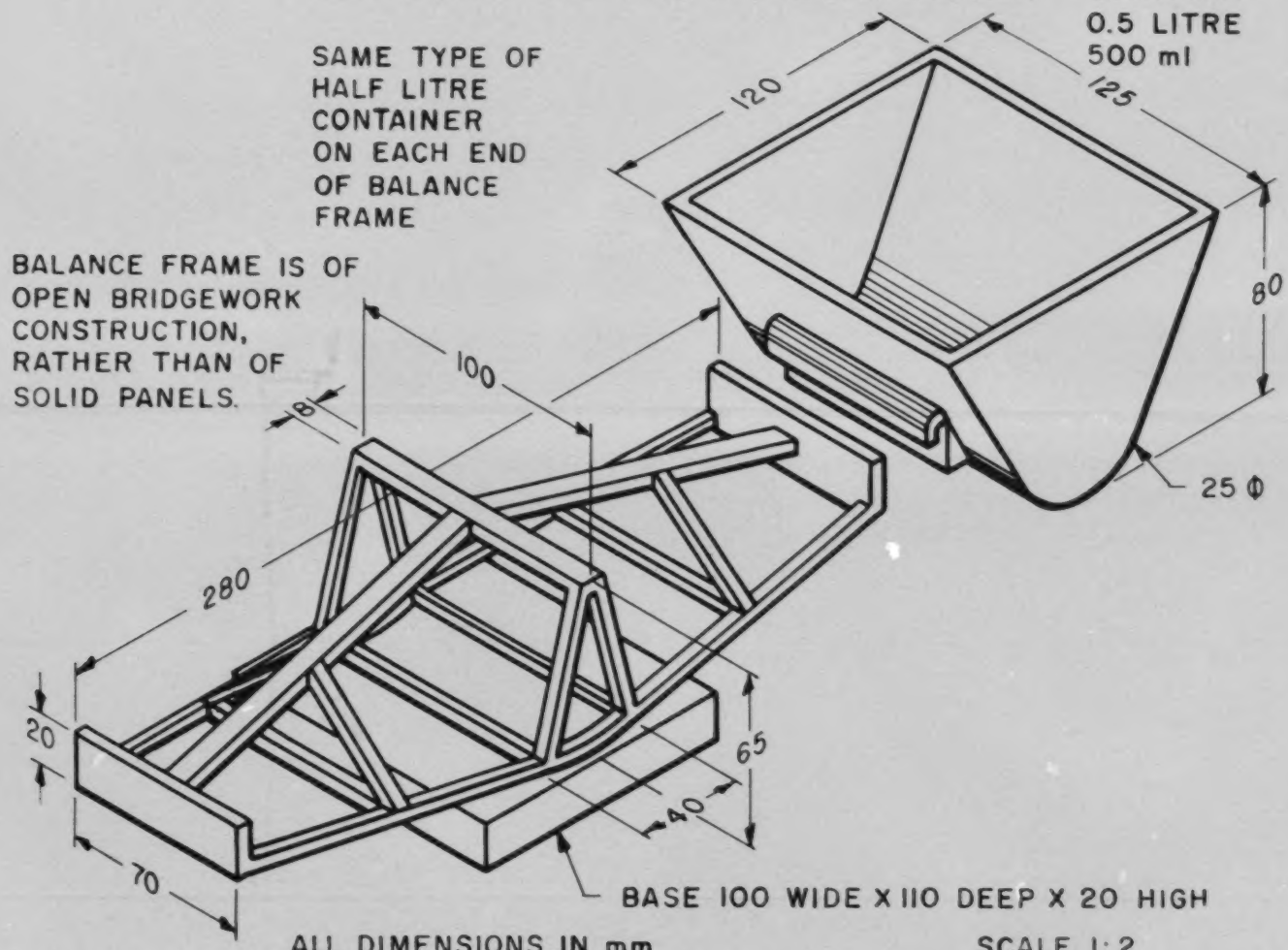


HALF LITRE BALANCE

CAPACITY:
0.5 LITRE
500 ml

SAME TYPE OF HALF LITRE CONTAINER ON EACH END OF BALANCE FRAME

BALANCE FRAME IS OF OPEN BRIDGEWORK CONSTRUCTION, RATHER THAN OF SOLID PANELS.



BASE 100 WIDE X 110 DEEP X 20 HIGH

ALL DIMENSIONS IN mm

SCALE 1:2

Section 5

DEVELOPING METRIC MATERIALS FOR PERSONS WITH SIGHT HANDICAPS

The fourth major objective of this study was to develop three dimensional material for teaching metrics to persons with sight handicaps. As a first step in developing this aspect of the project, a survey was made to find out what had been done in other countries now going metric to determine what they had accomplished in this area. Therefore, letters were sent to the metric conversion boards in Canada, South Africa, New Zealand, and Great Britain. A typical correspondence with the Metrication Board of Great Britain appears as Figure 5-1.

In addition, contacts were made with many of the leading blind organizations in this country including the American Printing House for the Blind, the American Foundation for the Blind as well as the Royal National Institute for the Blind in England. It is evident that very little attention has been given to developing materials for the blind in metric conversion.

As a first step in determining what material to develop, a meeting was held with Mr. Donald Blasch, Chairman of the Blind Rehabilitation Department at Western Michigan University and Mrs. Isabelle Smith, Acting Chairman of the Home Economics Department, Western Michigan University, who regularly teaches a course in home economics for the blind. The agenda for this meeting appears as Figure 5-2. It was determined that in addition to an agreement that learning devices should be developed for each of these items that the following should be done.

1. Contacts should be made at the American Printing House for the Blind regarding the materials they have available.
2. Contacts should be made with Hines Hospital in Chicago, who regularly work with blind individuals.
3. A meeting should be held with Mr. Russell Williams of the Veterans' Administration at Washington, D.C. who was in Kalamazoo on September 26, 1974.

Since Mr. William K. Purdy was hired as a consultant in this area, he was selected to make a trip to

Hines Hospital to determine what kinds of measuring instruments were used in vocational and technical work using the customary units. It was decided that these should be converted to metric units. His report on this trip appears as Figure 5-3.

As a result, it was decided to develop the following teaching aids:

1. Linear
   - A. Comparative units
     1. centimetre to inch
     2. 300 millimetres to 1 foot
     3. 150 millimetres to 6 inches
     4. 100 square centimetres to 4 inches square
     5. metre to yard
   - B. Tape measure
   - C. Skirt (hem) marker
   - D. Threaded gage
   - E. Blind rule
   - F. Cubic decimetre (10 parts)
   - G. Abacus
2. Capacity--Volume
   - A. Measuring cups
   - B. Measuring spoons
   - C. Balance scale with weights
   - D. Cubic decimetre weighing 1 kilogram
   - E. Comparative units
     1. 1 kilogram of butter to 1 pound of butter
3. Liquid Measures
   - A. Measuring cup with displacement discs
   - B. Dipper-type measuring spoons
   - C. Comparative units
     1. quart of milk to litre of milk

To perform these tasks would require persons with specialized skills in the world of woods and metals. It was necessary to build actual learning units of wood, plastic and metal that could be used by the blind in learning the metric system.

In developing these materials, two graduate students, who themselves were blind, made preliminary suggestions for changes and modifications. These students were Mr. Gary Johnson and Miss Sherry Hurdberg.

When the first prototypes were completed, Miss Elizabeth Lennon of the Blind Rehabilitation Department, was hired to assist in defining and finalizing the complete packet of materials. In the early stages of the

project, instructional material was planned to be prepared in braille. In fact, as an experiment, several recipes were converted to metrics and produced on large cards using a braille typewriter. However, at Miss Lennon's suggestion it was decided that it would be more practical to produce the material on tape since this would be easier to handle then the amount of involved material if the instructions were put in braille.

As a first step, scripts were prepared. These were then recorded by Mr. James Robinson of the Office of Instructional Communications, Western Michigan University. The original tape was made on a reel to reel tape. The material was then reviewed by Miss Lennon while completing each of the three programs. It was found that not enough time had been left between items for the sight-impaired student to actually examine the three-dimensional unit. Therefore, Miss Lennon suggested including time pauses after the item had been picked up and a time stop at the end of the instructions on each item so that the individual could examine the material closely. It was also decided that the ideal method would be to produce three separate tapes that could be used independently at each of the three stations.

Miss Lennon again reviewed these materials. Since she was not available to actually evalute the materials with individual students, she suggested that if the program was to be truly effective, it would be necessary to produce a handbook for the instructor or monitor. A copy of this handbook follows. This handbook includes each of the scripts for the three stations and identifies the items as A1, A2, B1, B2, and so forth. Photographs and complete drawings of each of the items follow the script.

To evaluate the material, Mr. Fred Mettlach, a Graduate Student in the Blind Rehabilitation Department, used seven students of various ages and backgrounds to go through the complete program. This was a very time consuming process since the evaluation was a one-to-one type relationship. In addition to the time required to complete the program, each subject was interviewed to determine the strengths and weaknesses of the program.

EVALUATION

The purpose of the evaluation was to determine the strengths and weaknesses of the material for the sight handicapped.* Since this instructional material has never been tested before, this report will have to be considered as preliminary. Further testing with a wider population would be ideal for more concrete evaluation. Not being involved in the development of the instructional materials, the viewpoint of this report is an individual perspective.

Overview of the Test

Tests were all monitored at the Center for Metric Education at Western Michigan University. The seven students tested were all graduates or undergraduates at the University. Of the seven, six were visually impaired and one was blindfolded. Four were congenital (blind from birth) and two were adventitious (both within the last six years).

The materials were set up on three different tables to coincide with the following learnings:

1. Station X - Length and Area
2. Station Y - Mass and Volume
3. Station Z - Typical Home-Use Items

The testees finished using materials at one station before progressing to the next. All instructions were given on cassette tape with adequate time to go from item to item at each station. A sighted monitor equipped with the HANDBOOK FOR TEACHING METRICS TO THE SIGHT HANDICAPPED (included with report) followed the tapes and answered any questions the testee may have had about the material.

At the end of the materials at Station Z, the monitor asked the participant the following questions:

1. Please state your name, address, educational background and career objective.
2. What is your overall opinion of the material on learning metrics?
3. Is the program complete enough for you to understand the common elements of SI metric?.
4. What specific suggestions do you have for improving the program?

---

*Fred J. Mettlach, Evaluation Consultant

5. What additional material would you like to see included in this program?

Descriptive data on each person includes sex, age, address, educational background, career objective, cause of blindness (congenital or adventitious) and length of time needed for completion of the program.

Subject 1 - Linda A.
Female
24 years old
Kalamazoo, Michigan
B.A. Elementary Special Education
Graduate Student - Adult Blind Rehabilitation, Western Michigan University
Congenital
2:30

Subject 2 - Marion H.
Female
22 years old
Kalamazoo, Michigan
B.A. Fine Arts
Graduate Student - Adult Blind Rehabilitation, Western Michigan University
Blindfolded (At the time no adventitiously blind persons were available for testing)
2:30

Subject 3 - Gayle H.
Female
24 years old
Kalamazoo, Michigan
B.A. Psychology
Graduate Student - Adult Blind Rehabilitation, Western Michigan University
Congenital
1:30

Subject 4 - Betty Z.
Female
Mid 40's
Kalamazoo, Michigan
Undergraduate - Special Education
Congenital
2:00

Subject 5 - Lucy E.
Female
Early 20's
Kalamazoo, Michigan
Undergraduate - Social Work
Plans to go into social work after receiving masters
Congenital
1:45

Subject 6 - Roberta K.
Female
Mid 20's
Kalamazoo, Michigan
B.S. Social Work, B.A. Biblical History
Graduate Student - Adult Blind Rehabilitation,
Western Michigan University
Adventitious (6 years)
1:30

Subject 7 - Paul P.
Male
33 years old
B.S., M.S., Ph.D. Botany
Graduate Student - Adult Blind Rehabilitation,
Western Michigan University
Adventitious (1 1/2 years)
1:50

Results, Recommendations, and Observations

The only souce of information to draw from for evaluation was the feedback of the participants and the observation of the monitor who conducted the study. Consequently, results and recommendations are not conclusive. They are open to further examination as to the merit and value of the instructional materials.

The results and recommendations can best be presented by asking the evaluative questions that were asked each participant at the end of the test. Some of the questions were answered with a consensus of opinion, and those will be summarized into one answer and any deviation will be answered more specifically.

"What is your overall opinion of the material on learning metrics?" The general consensus on this question was that the material was very good. The comparison of a metre and its components to a dollar and its components was thought to be an excellent method of presenting the concept. More interest was shown in Stations Y and Z because of their practical applications to everyday living. Materials were marked where they could be easily identified. Four out of the seven were initially overwhelmed by the amount of material that was given to them at Station X. All but one became more comfortable as the test progressed and items began relating to other items. Only one of the seven previously knew the metric system. The other six had little or no knowledge of it, and at the end of the test they felt that they had a better knowledge of the metric system.

"Is the program complete enough for you to understand the common elements of SI metric?" Again, the general consensus was that everyone did understand the basic elements of the system. There seems to be enough material in each of the stations to get an understanding of all the areas included. At Station X there could be some materials used for practical application of measurement. There were two people that did not fully understand the relationship between the Celsius and Fahrenheit scale. At Station X, the measuring gage was an item that was often questioned as to what it was, and after explanations, there were still questions about it.

"What specific suggestions do you have for improving the program?" No one seemed to care for the type of scale used in Station Y. A different kind of scale, preferably one where the pointer would not move so easily when touched, was recommended. A suggestion was made to try one with the pointer inside a small open window. More items dealing with practical applications of measurement should be used at Station X. The two hundred millimetre displacement disc was difficult to manipulate because of its size and shape. When a person poured water into the cup during this task, the water often stayed on top of the disc and confused the participant as to whether the water was in the cup or not. Suggestions were made to make the top of the disc round or cone shaped in order for the water to pour off.

"What additional material would you like to see included in this program?" There were not specific suggestions mainly because no one knew much, if anything, about metrics beforehand. The person who did know the metric system indicated that the materials were quite adequate for learning the basic metric system.

Some personal observations of the monitor may be of use in further studies. The participants who took more than an hour and forty-five minutes were all very tired by the end of the test. If someone is going to take a very long time, it may be advantageous to stop at the end of one station and continue at a later time with the next station.

Concepts are very important to a blind person, especially if he is congenital. Left and right and in front of and in back of are very basic concepts that must be known in order to locate items at each station. Make sure these concepts are present whenever presenting any of the material on this test.

This material developed by the Center for Metric Education was very well received by all those who participated in the project. They were glad to see that an effort was being made to include the visually impaired in something that will soon affect their daily living. The materials seem adequate to teach the basic metric system to the visually impaired, but the next step should be breaking the program down into separate components where they can be taught over a longer term. In this manner the materials can be more realistically evaluated.

Figure 5-1

August 27, 1974

Metrication Board
22 Kingsway
London WC2B 6LE
ENGLAND

Gentlemen:

We have recently been awarded a federal grant to develop metric teaching aids and instructional material for the blind.

We are wondering if your organization is working with blind citizens in your country regarding metric conversion, and if so, we would be interested in learning what type of materials you are using.

If samples of such material are available, we would appreciate receiving copies of them.

Sincerely,

John L. Feirer, Director
Center for Metric Education

jr

Metrication Board
22 Kingsway London WC2B 6LE
Telephone 01-242 6828

24 September 1974

Dr John L Feirer
Director
Centre for Metric Education
Western Michigan University
KALAMAZOO
Michigan 49001
USA

Dear Dr Feirer

Thank you for your letter of 27 August about metric teaching aids and instructional material for the blind.

The Board has not produced any teaching material for this sector of the community and I have been unable to locate any commercially produced aids. I have therefore turned to Mr W B Poole, Braille Editor of the Royal National Institute for the Blind, for assistance. I have sent Mr Poole a copy of your letter and asked if he will be good enough to get in touch with you direct. His address, in case you need it, is: 224 Great Portland Street, London, W1N 6AA.

Yours sincerely

(Mrs) P M JOLLY
Head of Education and Industrial Training

Figure 5-2

AGENDA

METRIC MEASURING EQUIPMENT FOR THE BLIND

I. General purpose of the project
II. General needs of the blind in using measuring instruments
III. Linear measurement
    A. Kinds of scales
        1. 300 millimetre
        2. marking gage
        3. combination square
    B. Smallest readable division--2 mm or 5 mm?
    C. Comparison units
        1. centimetre with inch
        2. 300 millimetres with foot
        3. yard to metre
    D. Material to use
        1. wood
        2. plastic
        3. metal
        4. advantages/disadvantages of each
IV. Area measurement
    A. One square decimetre marked in square centimetres
    B. Comparative units
        1. square centimetre with square inch
        2. square decimetre with 4 inches square
        3. anything larger?
    C. Solid volume
        1. cubic centimetre--cubic decimetre
        2. comparative units
V. Liquid volume or capacity
    A. Litre container
    B. 250 millilitre cup
    C. How to obtain accurate measurements of less than a litre or 250 millilitres
    D. Comparative units
    E. Problems in measuring liquids
VI. Experimenting with metric measuring units for the blind
    A. Groups to be used
    B. How to do it

Figure 5-3

MEMORANDUM

TO: John L. Feirer
From: Bill Purdy
Subject: Trip to Hines Hospital
Date: November 19, 1974

On November 13 and 14, 1974, I traveled to Hines Veterans' Administration Hospital to discuss with the staff at the Blind Rehabilitation Center metric learning aids for the blind. I took what materials we have prepared here at Western to ask their advice on them and then to ask advice on such items as how the blind measure solid and liquid volume, and how they measure temperatures.

My contact person at the Hospital was Mr. John Thompson. He is administrator of the blind instructional staff. Mr. Thompson was most cooperative and helpful, as were all members of his staff.

On Wednesday afternoon I discussed with Mr. Thompson what materials we have available and asked questions as I indicated previously. He set up a meeting with his staff members for Thursday morning, November 14, 1974. In this meeting I explained to the staff members what the units were for that we have developed, and they seemed to feel that most things we have are excellent materials and can readily be used by blind people in learning the metric system. The one item that most staff members felt was the most significant is some kind of ruler with an adjustable stop on it that students can use to measure length with, such as the one we already have in standard units.

We discussed how fine the markings should be on such a ruler, and it was decided that every other millimetre would be sufficient since many blind people also have tactual difficulties and find it exceedingly difficult to feel fine differences. It was further suggested that such a ruler should have grooves cut in it that could be felt with the fingernail and at each centimetre a raised portion to readily identify the difference between millimetres and centimetres. Since much work is done with an awl as far as marking is concerned, it was suggested that a small groove be cut in the end of the ruler in which an awl could be placed at the zero mark so they could readily locate the beginning of the ruler. Most of the other measuring units that we discussed seemed to be nice-to-have items but most

blind people didn't use anything except the rulers that we have discussed.

The home economics instructor discussed the volume measuring problem, and we discovered that there is an audible device in use by the blind that can be adjusted for different heights. As liquid is poured into a container, it creates a circuit between two probes, which sounds an audible tone to indicate that the liquid has reached a certain level.

As far as dry volume is concerned, it was suggested that metric units be made which would be standardized throughout the country so that each unit would be a specific metric quantity. The dry materials could then be filled to the top and scraped level to indicate that a certain quantity had been reached. The metric measuring spoons that we have from New Zealand seem to be a popular item if it could be indicated on them in braille what the quantities are and the recipes recommended that these quantities are part of their measuring system. The problem arose--what do you do when there is a recipe that asks for two millilitres and your spoon only measures two and one half millilitres? This is where standardization would have to occur between the people writing the recipes and the manufacturer of the measuring units.

We also discussed measuring temperatures for blind, and it was concluded that the standard practice is to take a dial-type thermometer using the Celsius unit, remove the cover and use the pointer to feel where the temperature is and have a series of reference dots or raised marks to indicate the different temperature levels. There is also an audible device available, which sounds a certain tone at certain temperatures.

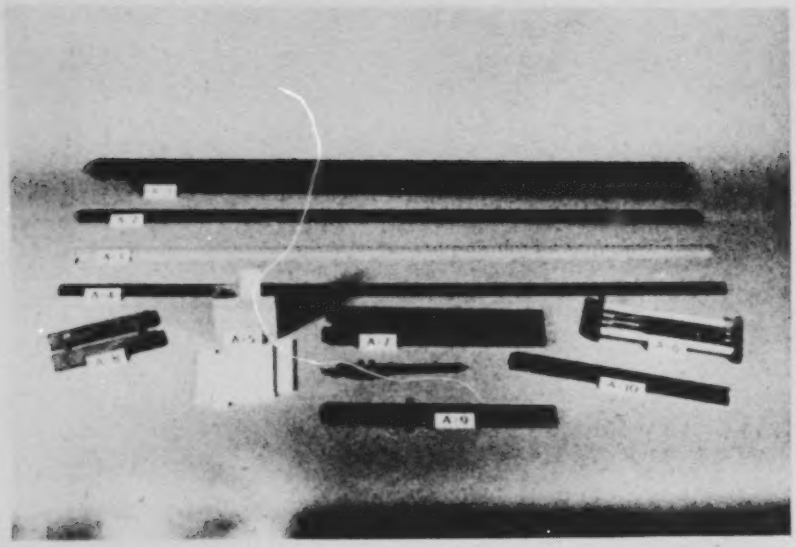
One other method for measuring volume was discussed and this was using a balance scale. It was indicated that there is a scale available from blind supply houses which indicates a tone when a balance has been reached between a set portion and a variable quantity. It was not known whether this scale was available in metric units or American standard units.

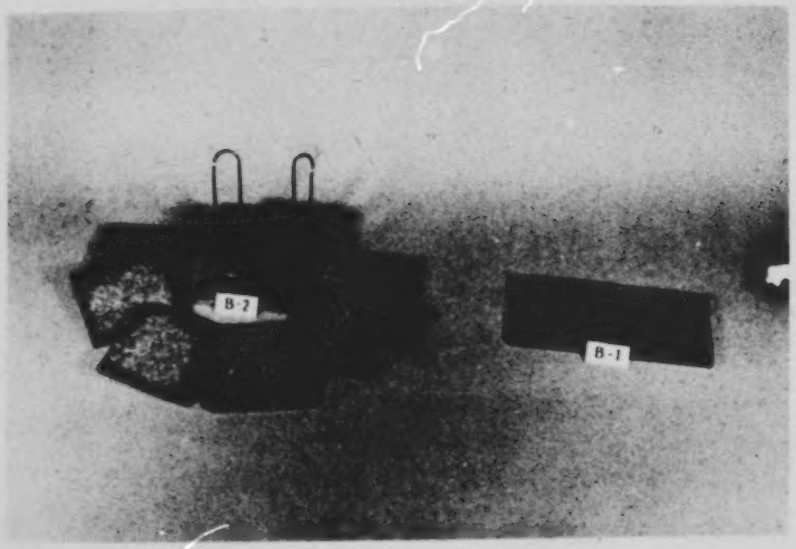
I was given a number of addresses for companies which supply materials for the blind to which we could write and obtain materials and information on creating these metric units for the blind. The addresses are as follows:

1. The Howe Press
   175 North Beacon Street
   Watertown, Massachusetts 02172
   They have a catalog available
2. The Royal National Institute for the Blind
   224 Great Portland Street
   London W1N6AA
   England
   This company may have metric units since it is in England.
3. The American Printing House for the Blind
   1839 Frankfort Avenue
   Louisville, Kentucky 40206

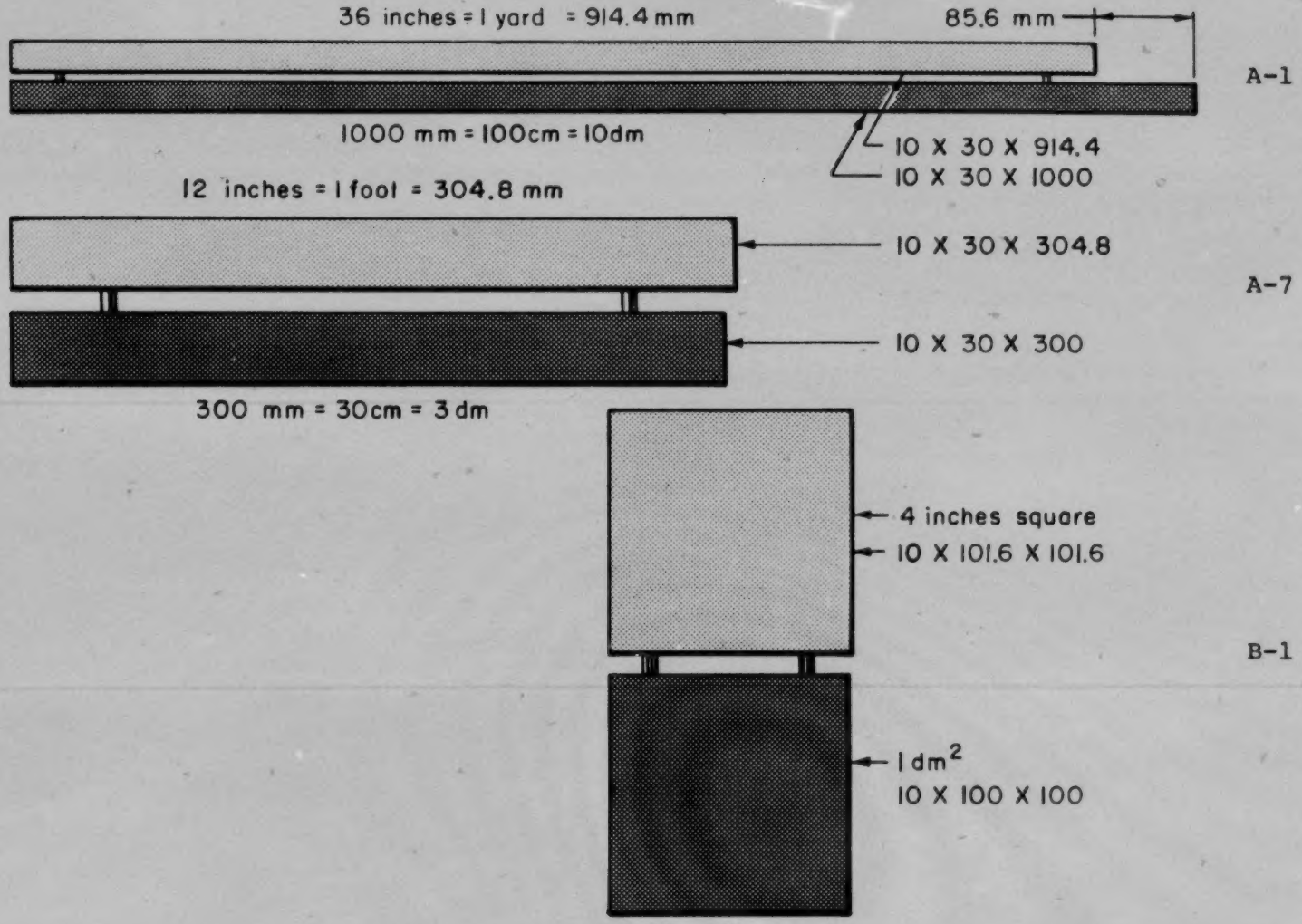
The next two are companies which manufacture items for the blind; one of these items is the liquid-level indicator.

1. G. A. Gambel
   2902 Garden Ridge
   Des Moines, Iowa 50310
   This company is one that manufactures items as well as special order items for people that have a particular item that needs to be manufactured for the blind.
2. Science for the Blind
   221 Rock Hill Road
   Bala-Cynwyd, Pennsylvania 19004
   This company had the best liquid-level indicator.

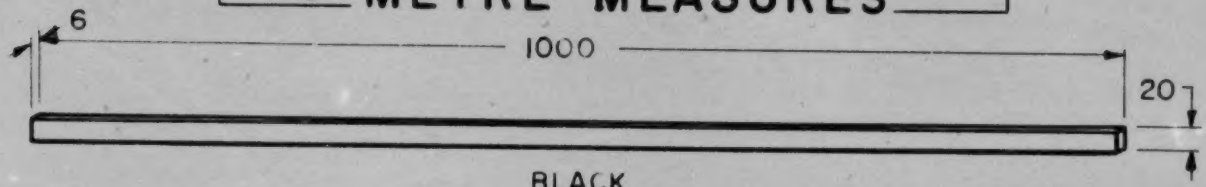




95


36 inches = 1 yard = 914.4 mm
85.6 mm
A-1
1000 mm = 100cm = 10dm
10 X 30 X 914.4
10 X 30 X 1000
12 inches = 1 foot = 304.8 mm
10 X 30 X 304.8
A-7
10 X 30 X 300
300 mm = 30cm = 3 dm
4 inches square
10 X 101.6 X 101.6
B-1
1 dm²
10 X 100 X 100

METRE MEASURES

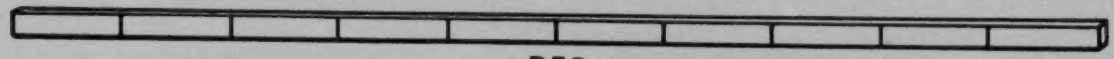


A-2

BLACK

ONE METRE NO GROOVES

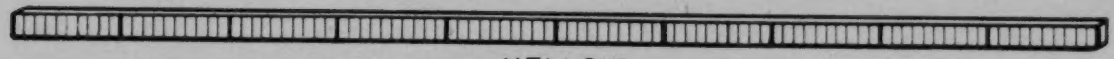
ALL DIMENSIONS IN mm



A-3

RED

TEN DECIMETRES
9 DEEP GROOVES, 10 cm APART

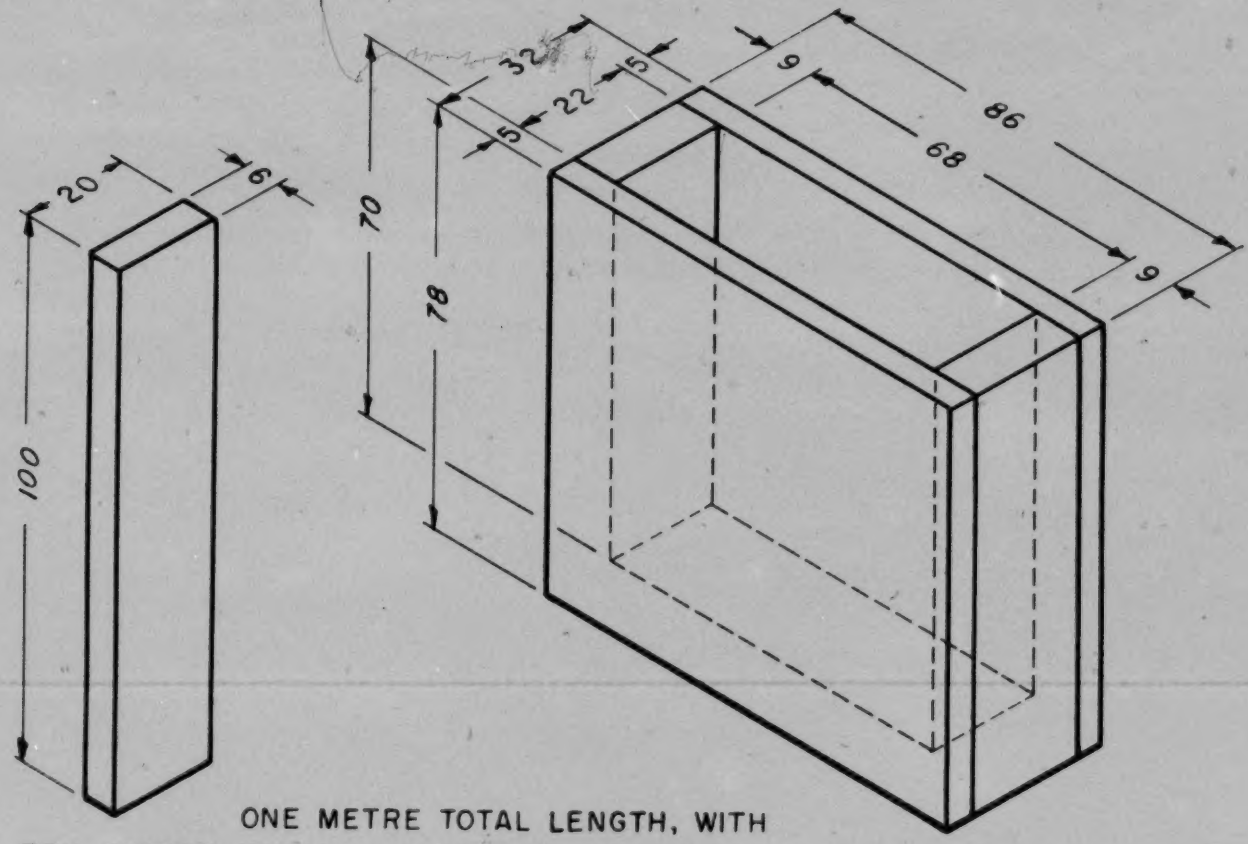


A-4

YELLOW

ONE HUNDRED CENTIMETRES
9 DEEP GROOVES, 10 dm APART
9 LESSER GROOVES, 100 cm APART

TEN PIECES AND CONTAINER



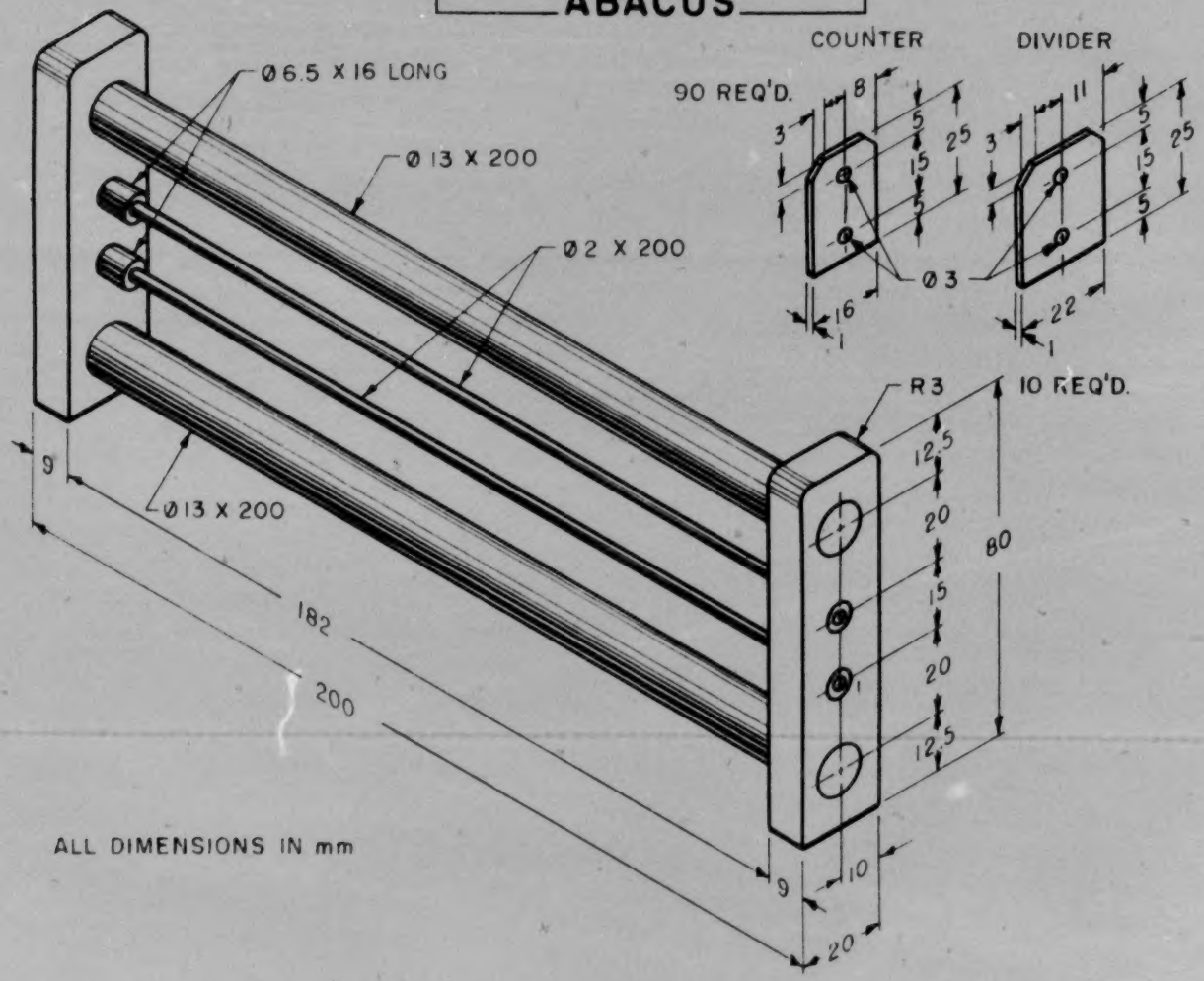
ONE METRE TOTAL LENGTH, WITH TEN PIECES, ONE DECIMETRE LONG, IN A ROW.

CONTAINER

ALL DIMENSIONS IN mm

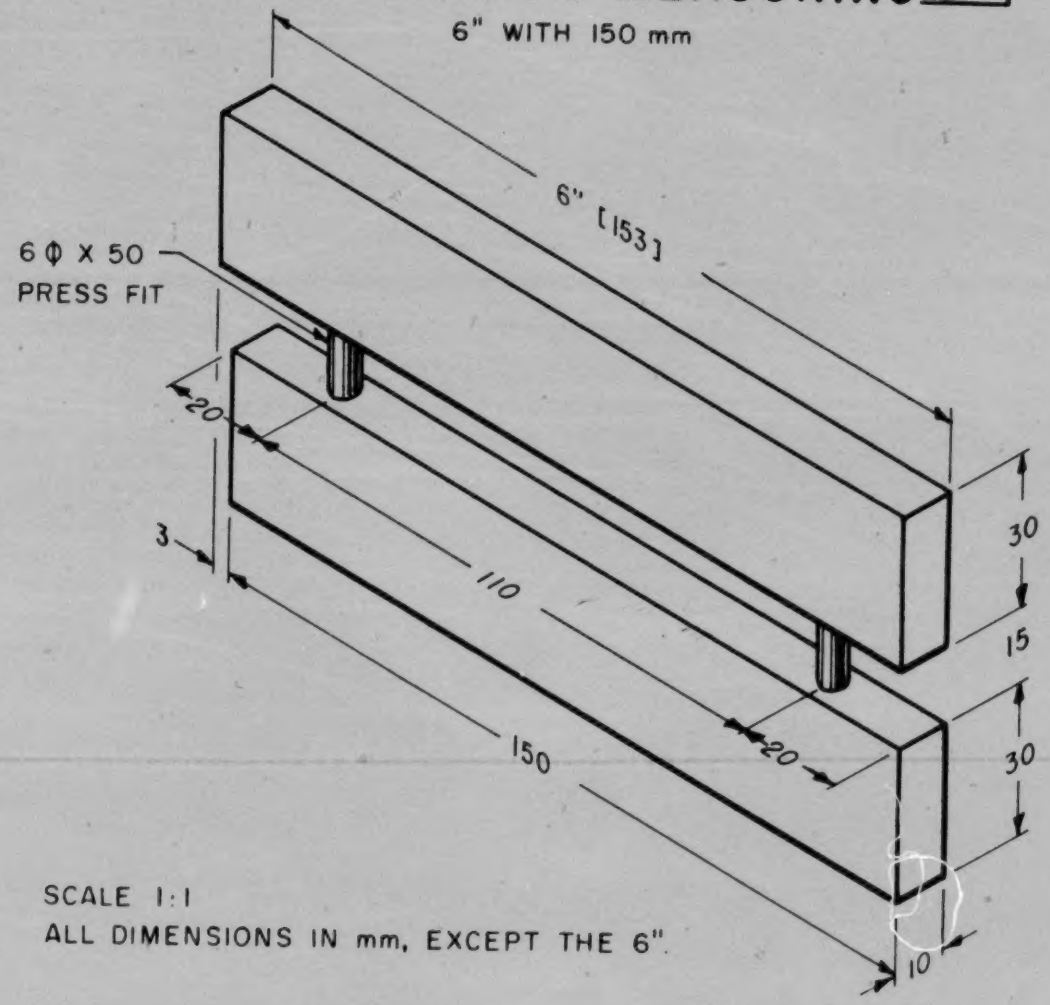
A-5

ABACUS


COUNTER
DIVIDER
90 REQ'D.
Ø6.5 X 16 LONG
Ø13 X 200
Ø2 X 200
Ø13 X 200
Ø3
R3
10 REQ'D.
ALL DIMENSIONS IN mm

A-6

COMPARISON MEASURING



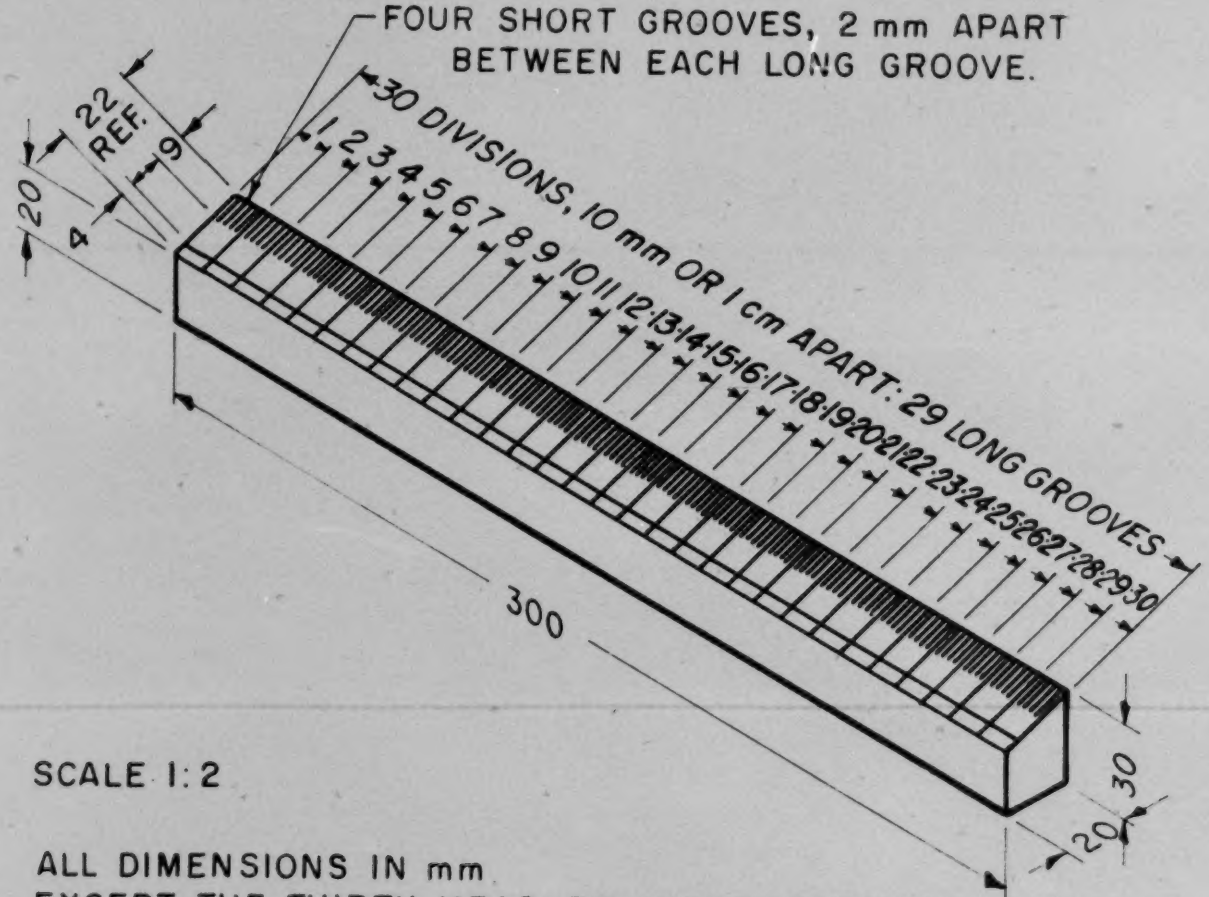
A-8

SCALE 1:1
ALL DIMENSIONS IN mm, EXCEPT THE 6".

131

132

30 CENTIMETRE MEASURE

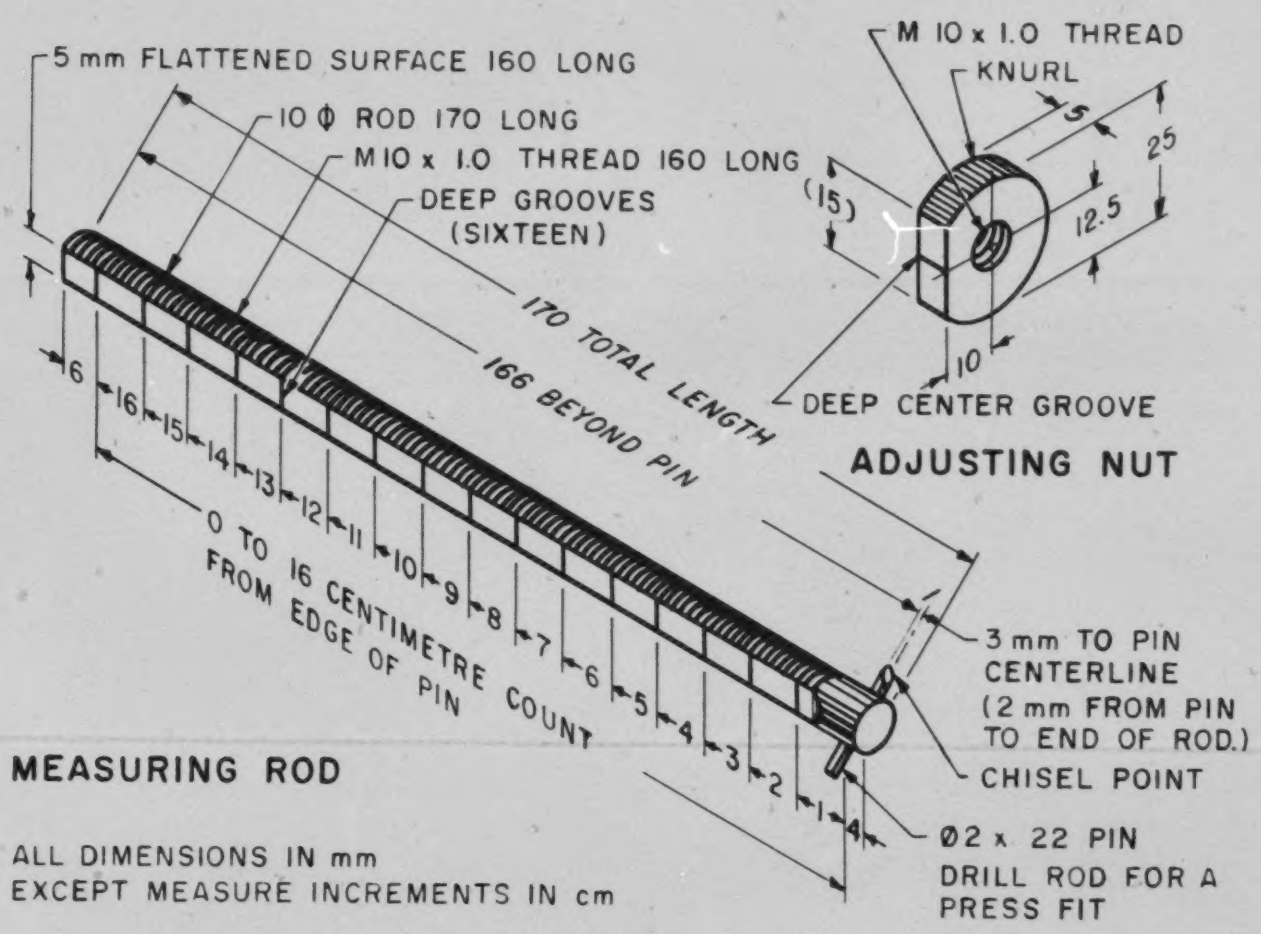

FOUR SHORT GROOVES, 2 mm APART
BETWEEN EACH LONG GROOVE.
30 DIVISIONS, 10 mm OR 1 cm APART: 29 LONG GROOVES
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
22
REF.
9
20
4
300
30
20

SCALE 1:2

ALL DIMENSIONS IN mm
EXCEPT THE THIRTY MEASURE INCREMENTS IN cm.

A-10

ADJUSTABLE CENTIMETRE MEASURE

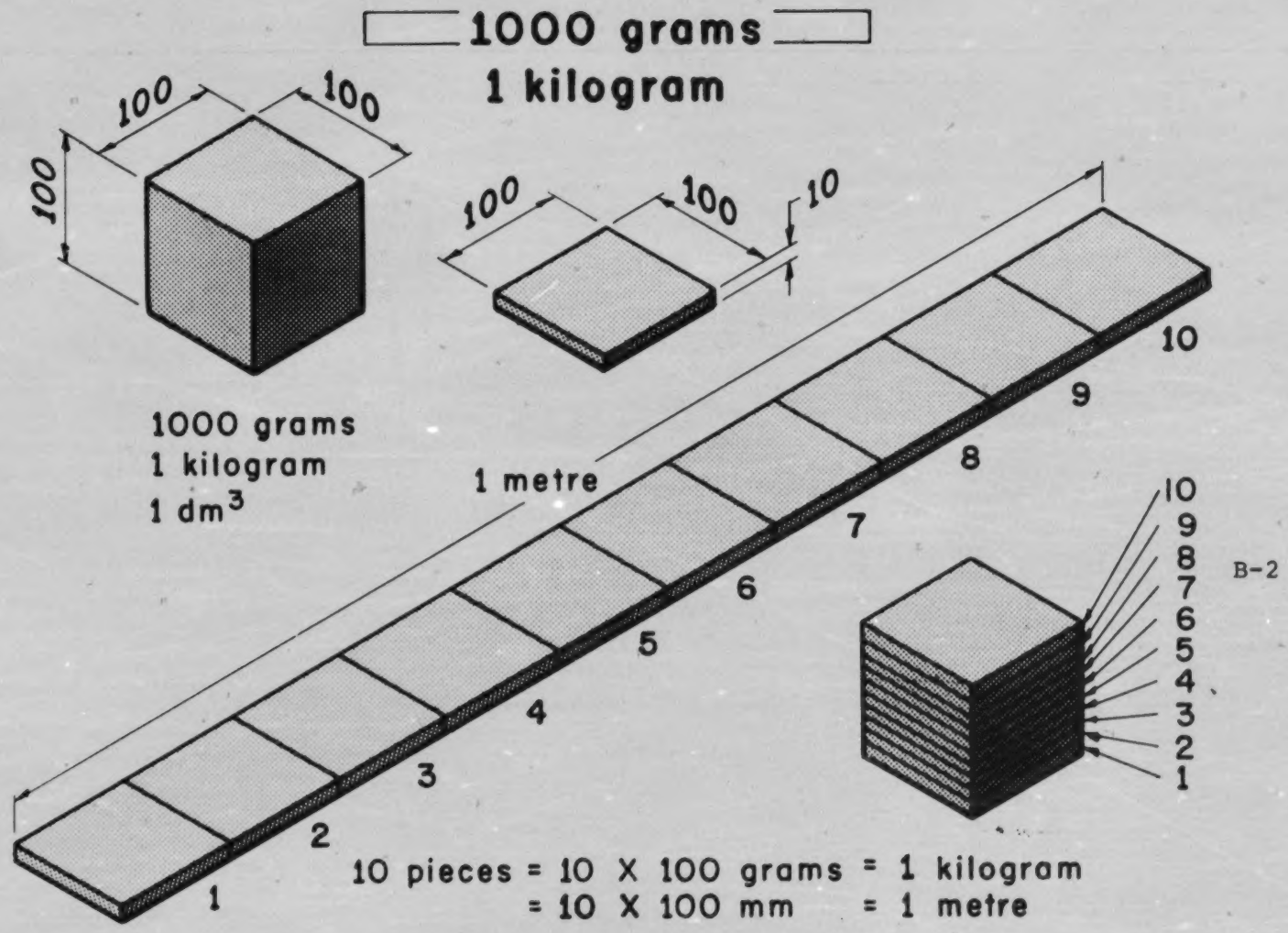

5 mm FLATTENED SURFACE 160 LONG
10 Φ ROD 170 LONG
M10 x 1.0 THREAD 160 LONG
DEEP GROOVES (SIXTEEN)
170 TOTAL LENGTH
166 BEYOND PIN
6 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 4
0 TO 16 CENTIMETRE COUNT FROM EDGE OF PIN
MEASURING ROD
M 10 x 1.0 THREAD
KNURL
5
25
12.5
(15)
10
DEEP CENTER GROOVE
ADJUSTING NUT
3 mm TO PIN CENTERLINE (2 mm FROM PIN TO END OF ROD.)
CHISEL POINT
Ø2 x 22 PIN
DRILL ROD FOR A PRESS FIT

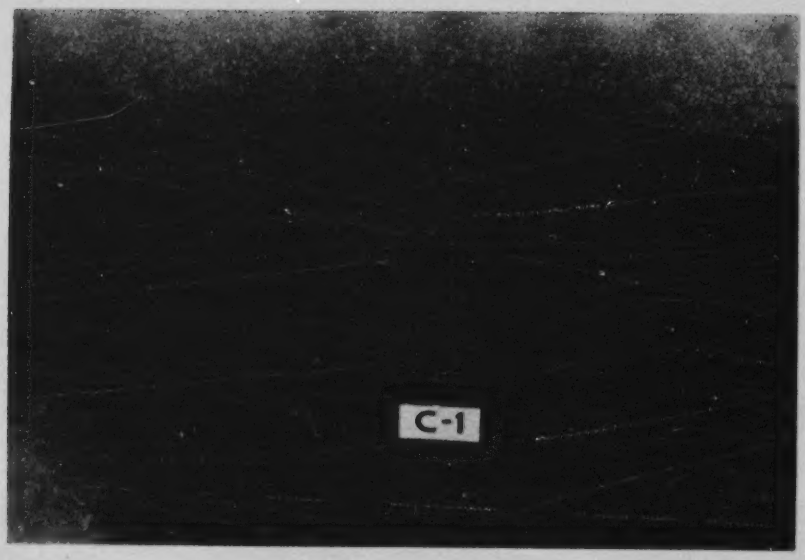
A-11

ALL DIMENSIONS IN mm
EXCEPT MEASURE INCREMENTS IN cm

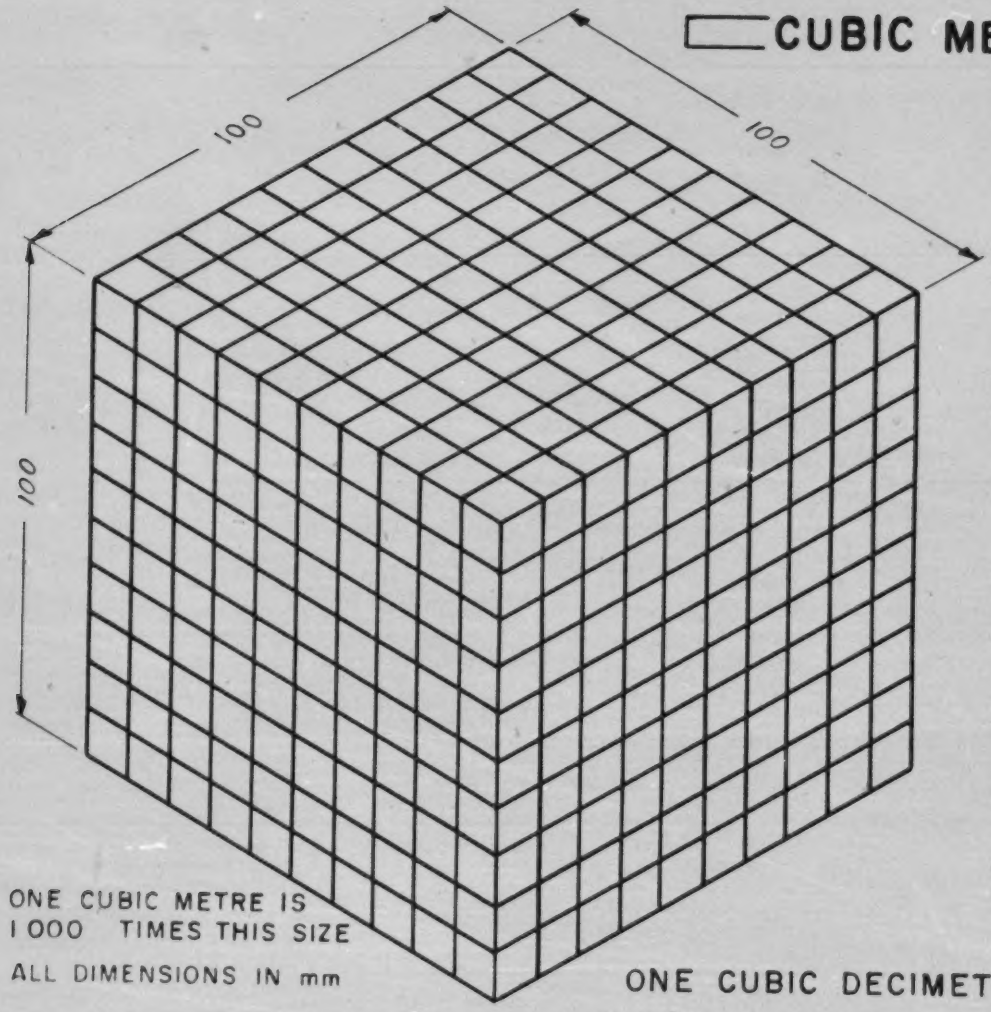
135

136


1000 grams
1 kilogram
100
100
100
100
100
10
1000 grams
1 kilogram
1 dm3
1 metre
1
2
3
4
5
6
7
8
9
10
10
9
8
7
6
5
4
3
2
1
B-2
10 pieces = 10 X 100 grams = 1 kilogram
= 10 X 100 mm = 1 metre


C-1

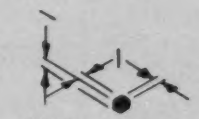
CUBIC MEASURE



ONE CUBIC METRE IS
1 000 TIMES THIS SIZE

ALL DIMENSIONS IN mm

ONE CUBIC DECIMETRE

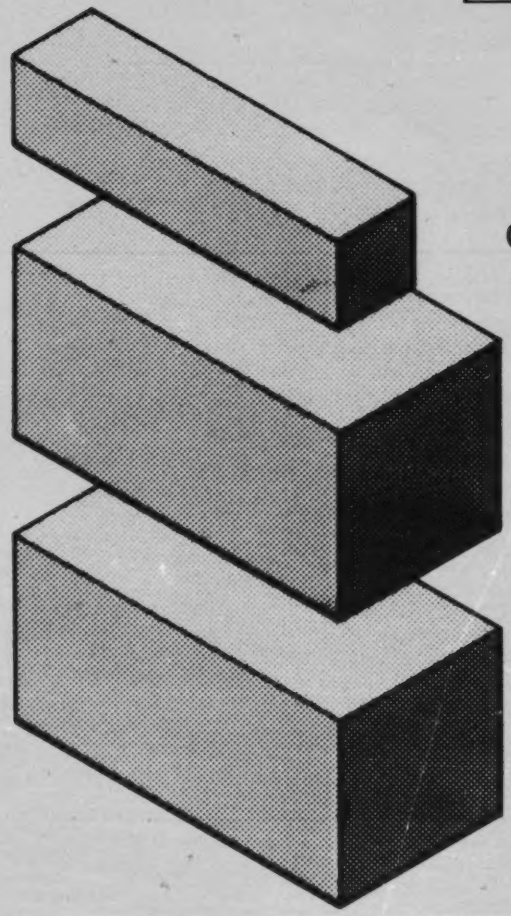


ONE CUBIC
MILLIMETRE

C-I and
D-1

ONE CUBIC
CENTIMETRE

BUTTER

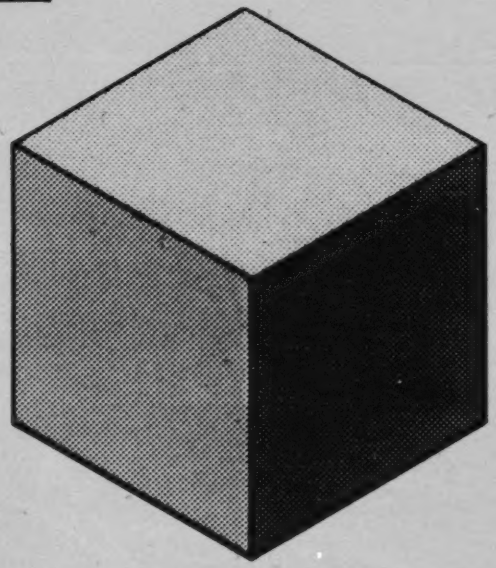


0.2 pound

1.0 pound

1.0 pound

2.2 pounds of butter



C-2

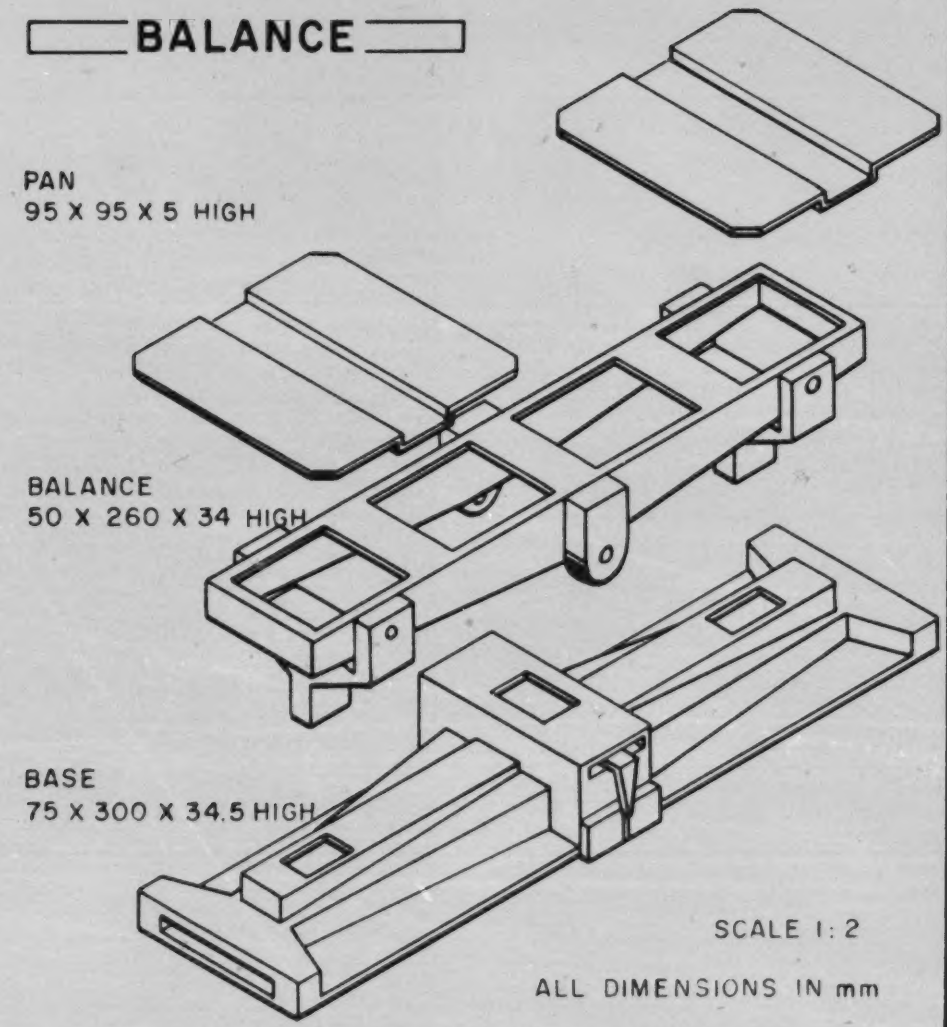
1 kilogram

1000 grams

1 dm^3

2.2 pounds = 1 kilogram

BALANCE

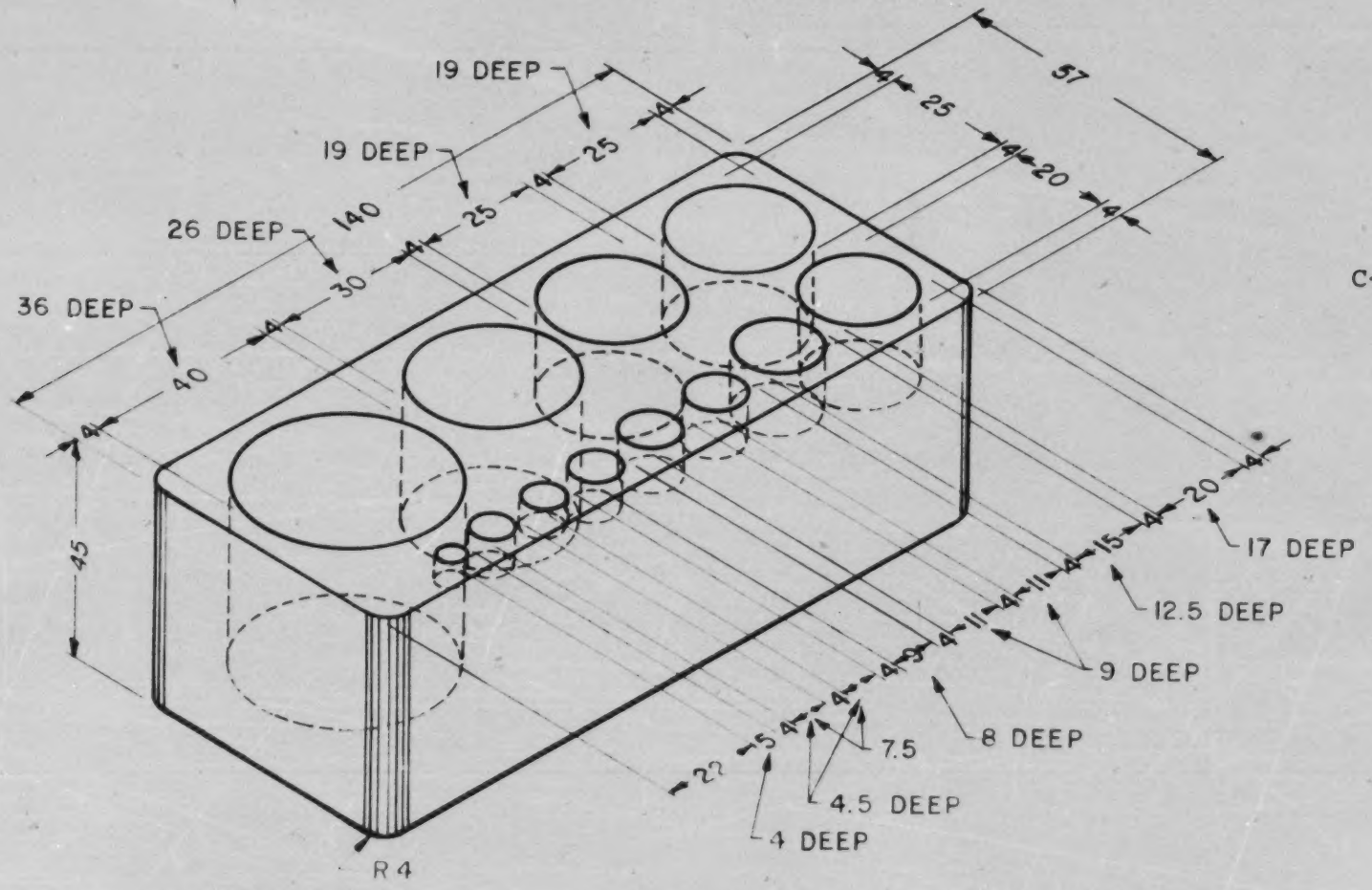


SCALE 1: 2

ALL DIMENSIONS IN mm

141

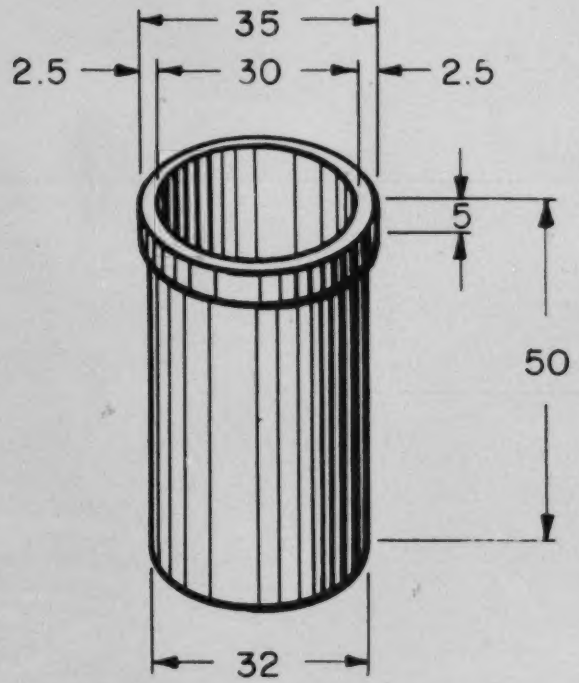
BOX FOR GRAM WEIGHTS



C-4

ALL DIMENSIONS IN mm

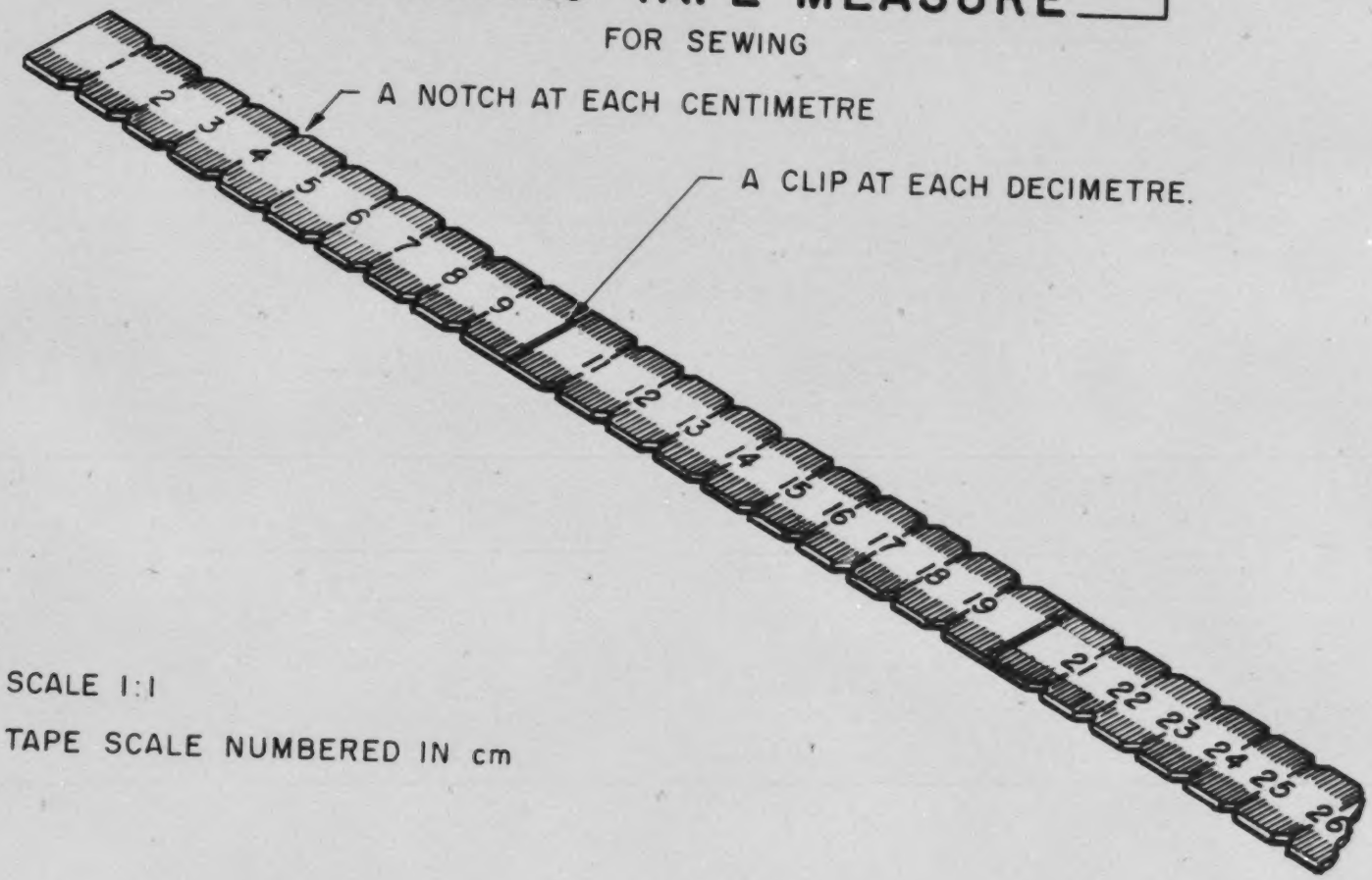
PLASTIC CONTAINER



SCALE 1:1
ALL DIMENSIONS IN mm

METRIC TAPE MEASURE

FOR SEWING

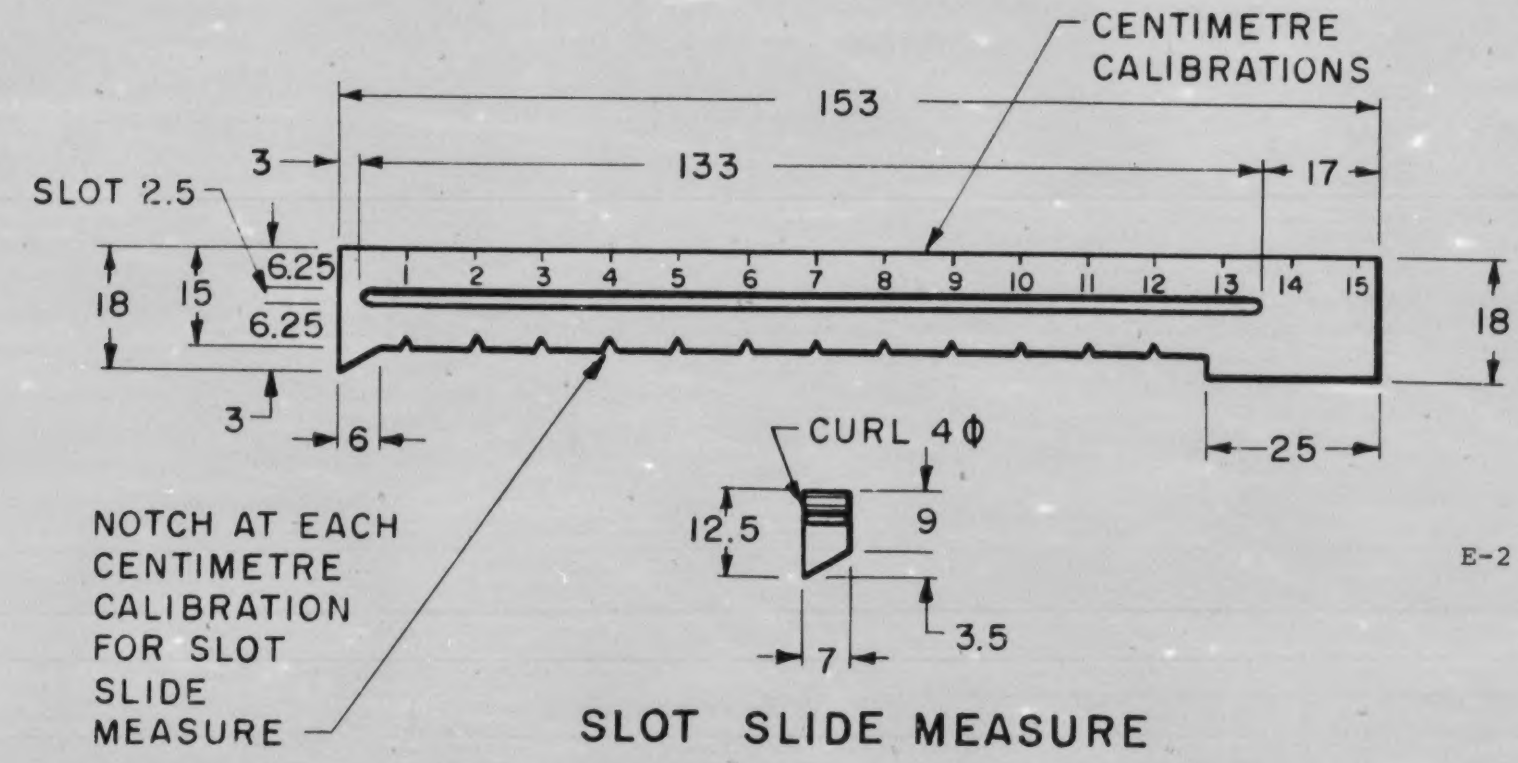


E-1

SCALE 1:1

TAPE SCALE NUMBERED IN cm

CENTIMETRE SEWING MEASURE



SLOT SLIDE MEASURE

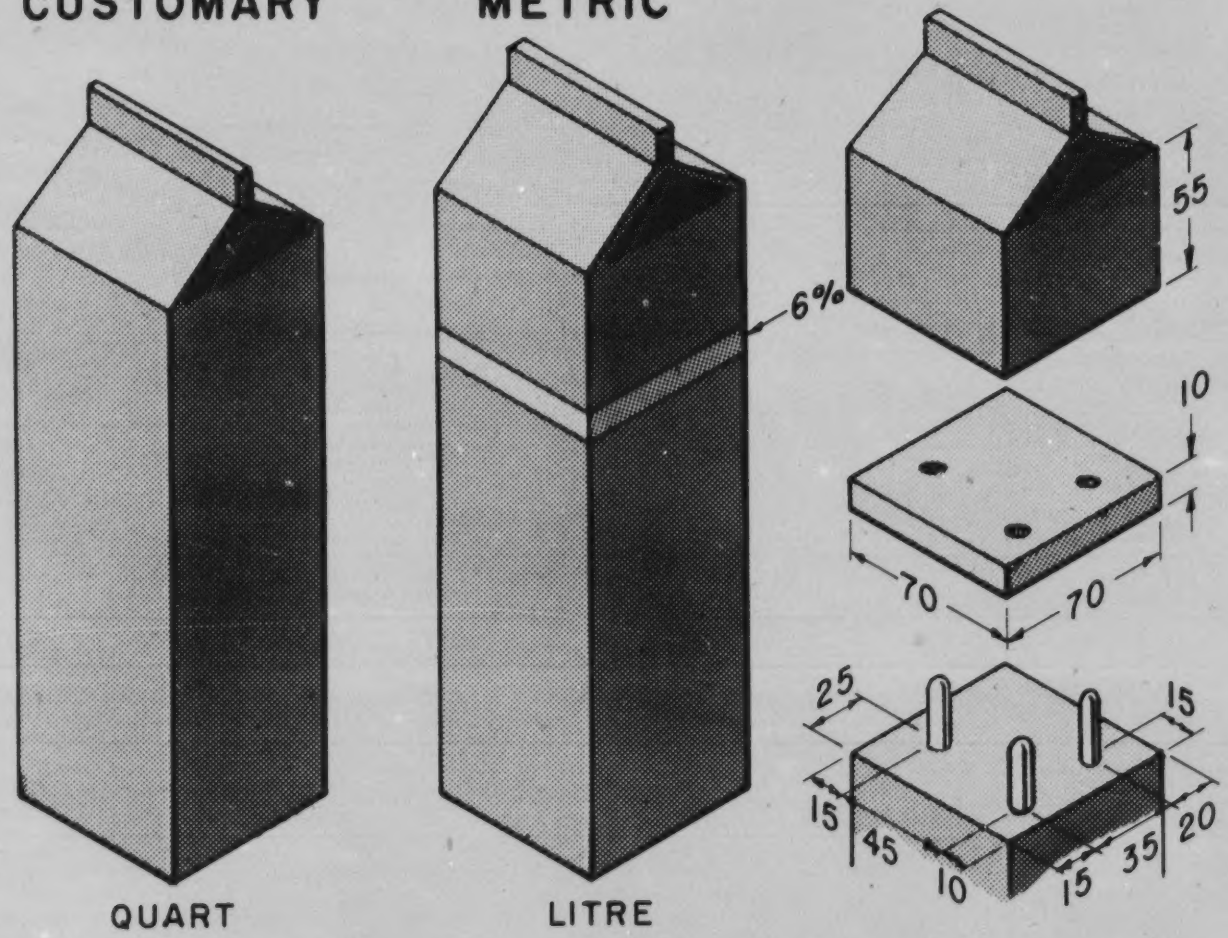
SCALE 1:1

ALL DIMENSIONS IN mm, EXCEPT THE cm SCALE.

MILK

CUSTOMARY

METRIC



QUART

LITRE

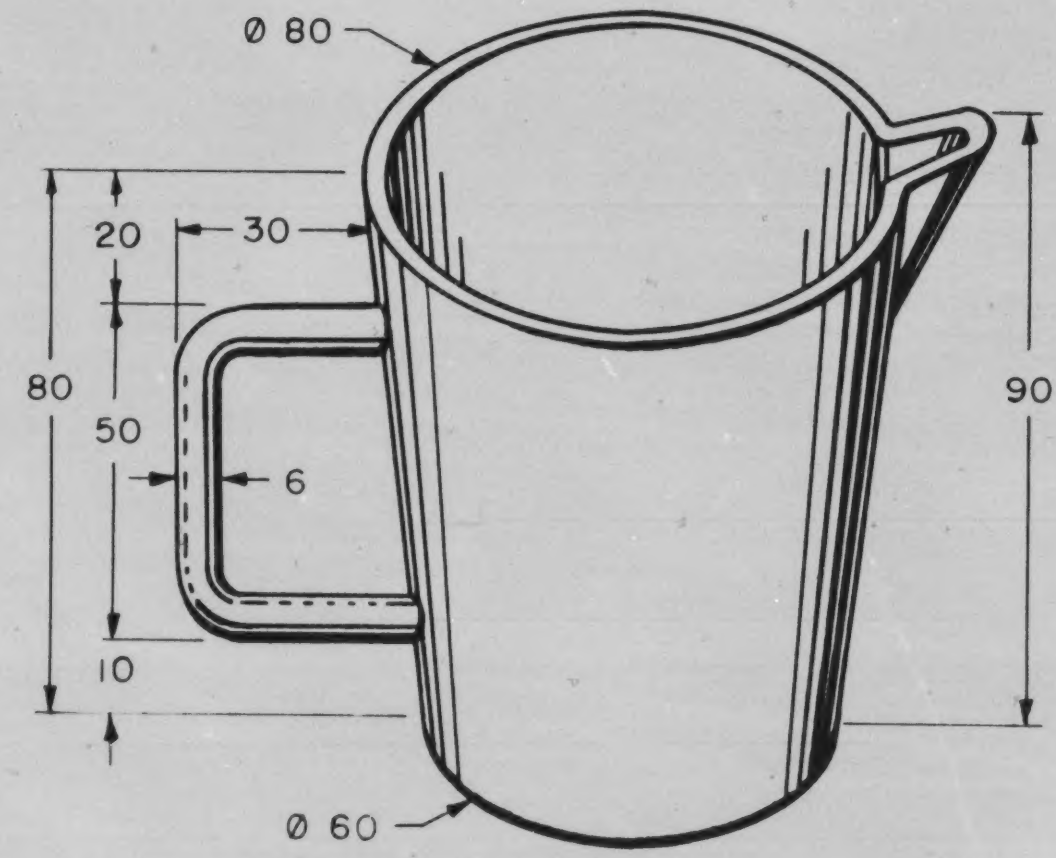
E-3

152

153

CUP MEASURE

E-4a

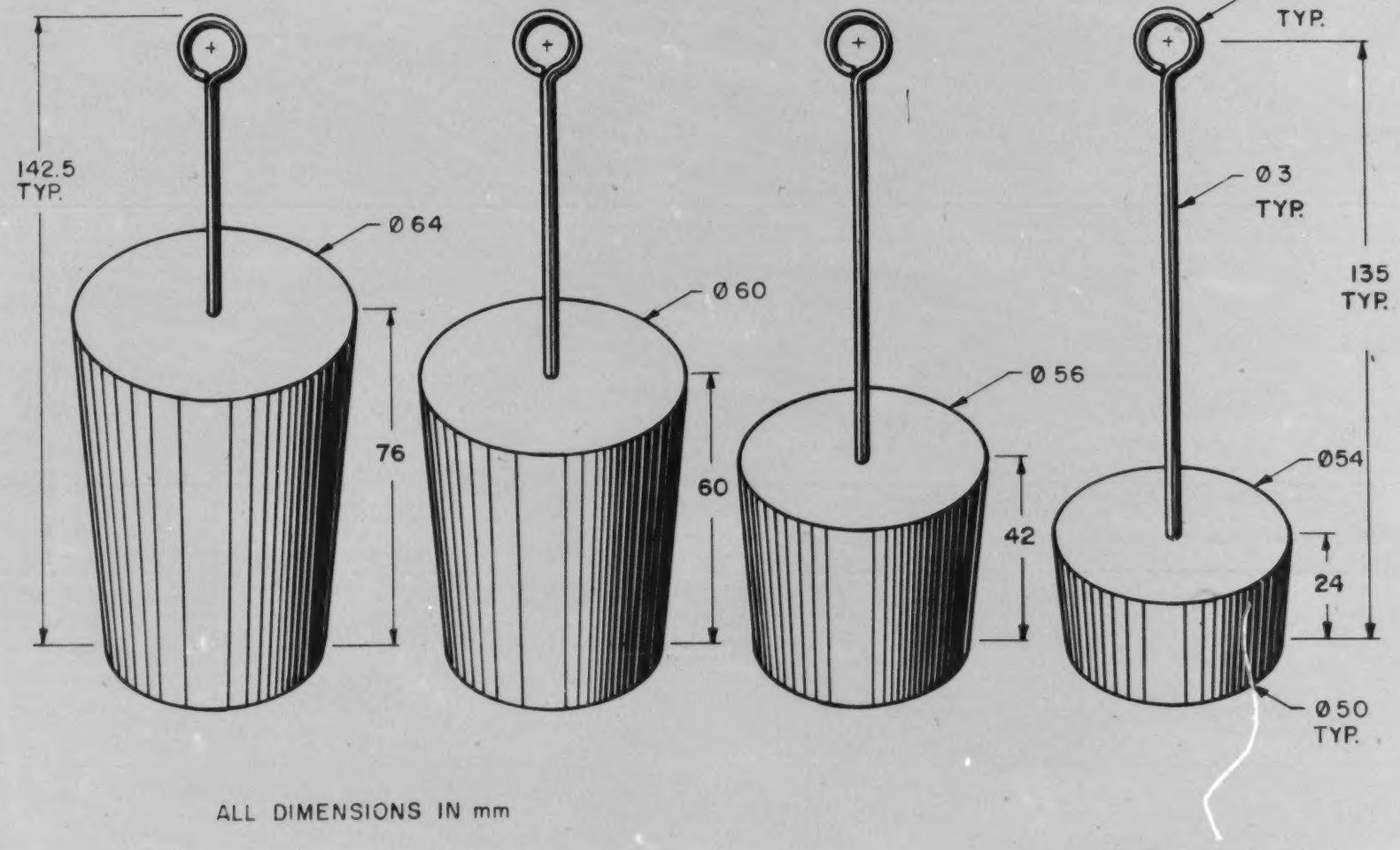


SCALES		
CUSTOMARY		METRIC
CUP	OUNCE	ml
1	8	250
$\frac{3}{4}$	6	200
$\frac{1}{2}$	4	150
		100
$\frac{1}{4}$	2	
		50
0	0	00

ALL DIMENSIONS IN mm

E-4b

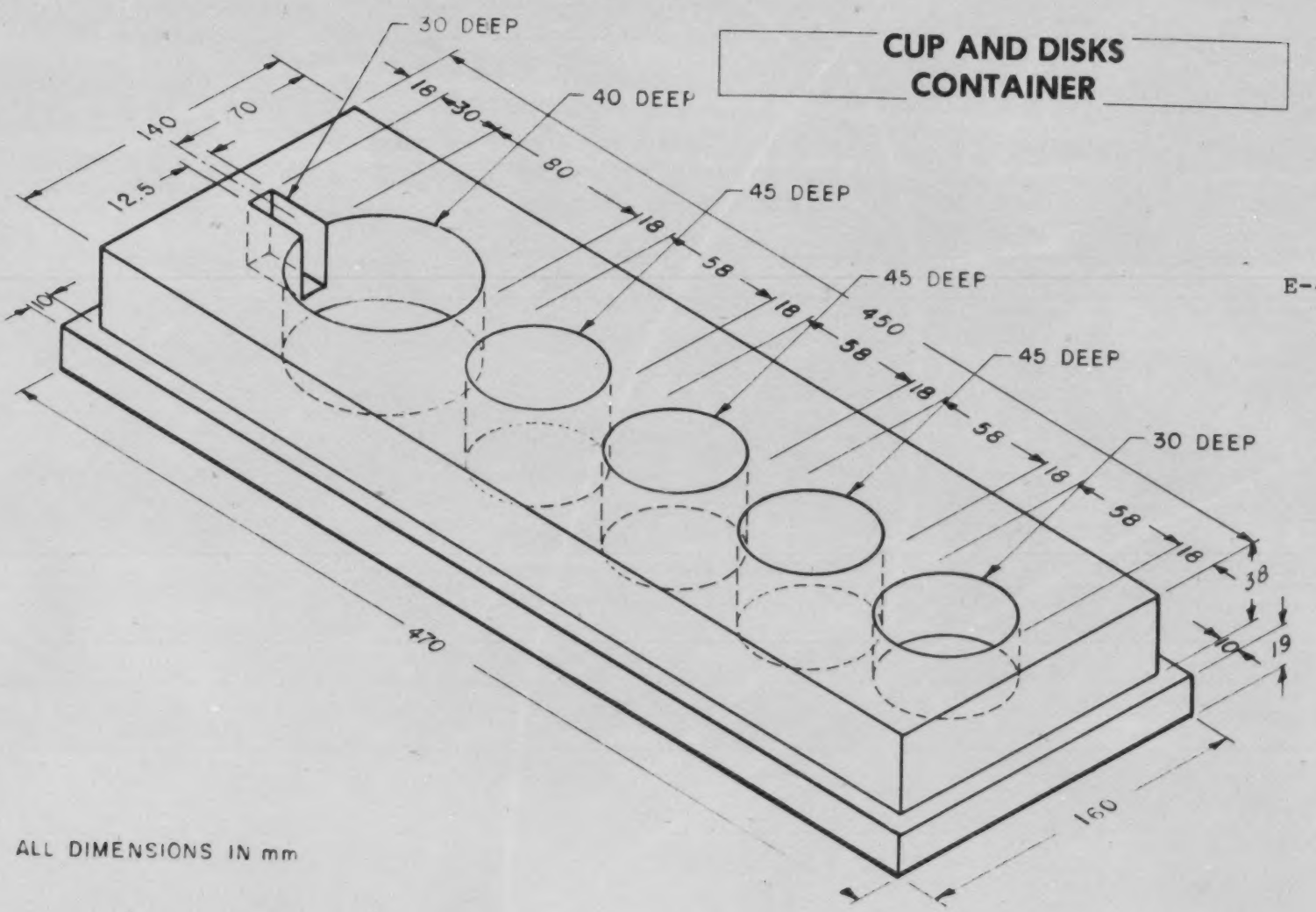
DISPLACEMENT DISKS



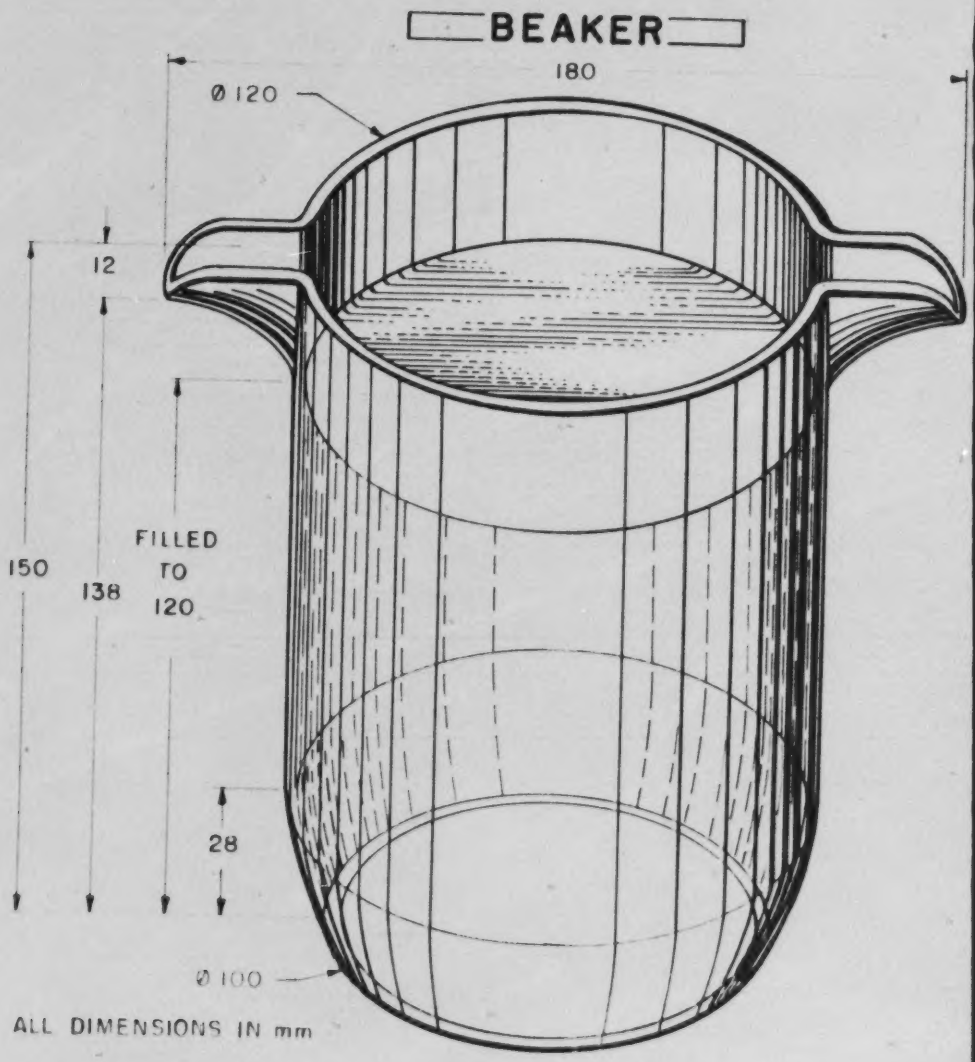
ALL DIMENSIONS IN mm

CUP AND DISKS CONTAINER

E-4c



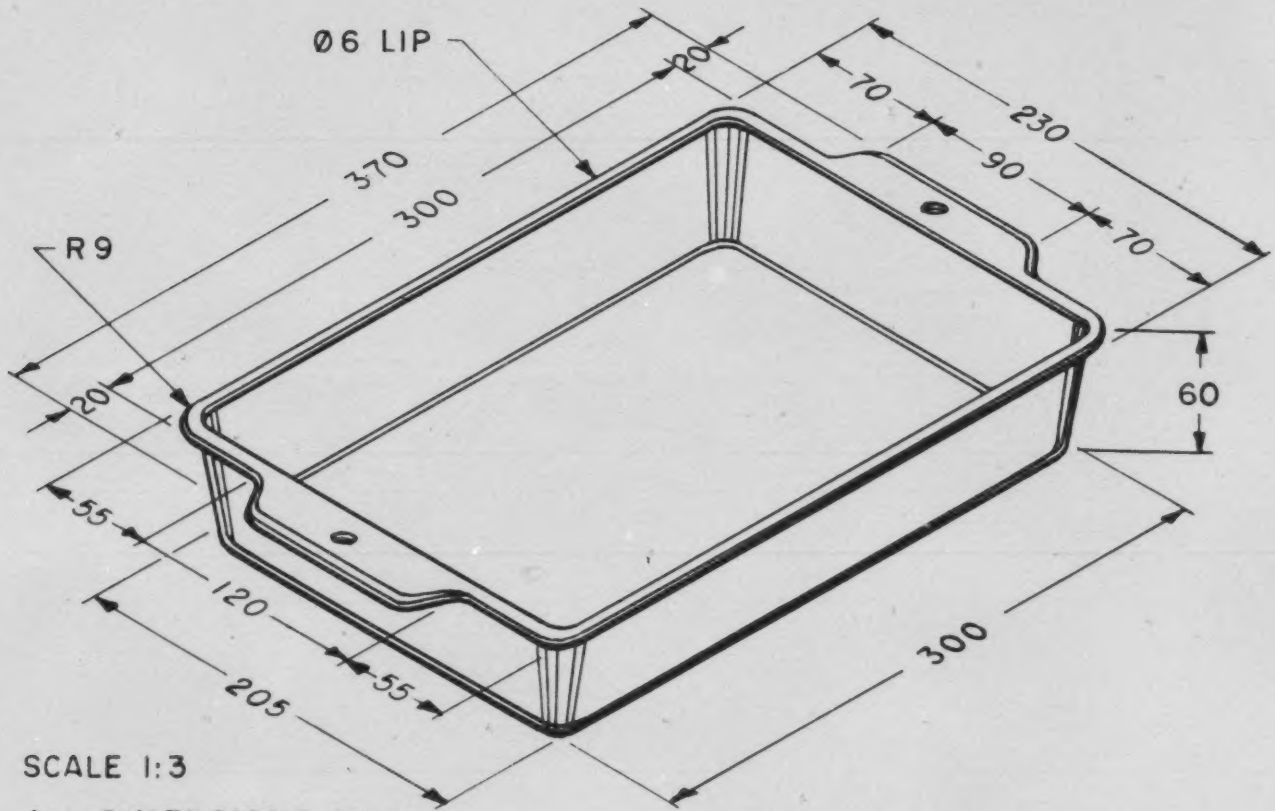
ALL DIMENSIONS IN mm


BEAKER
180
Ø 120
12
150
138
FILLED
TO
120
28
Ø 100
ALL DIMENSIONS IN mm

116

RECTANGULAR PAN

E-4e



SCALE 1:3

ALL DIMENSIONS IN mm

METAL MEASURING SPOON SET

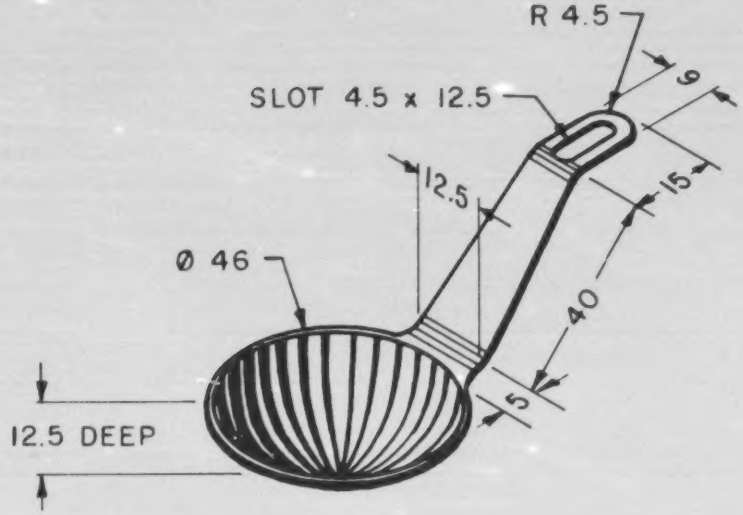
ONE QUARTER TEASPOON
1.25 ml

ONE HALF TEASPOON
2.5 ml

ONE TEASPOON
5 ml

ALL DIMENSIONS IN mm

ONE TABLESPOON
15 ml



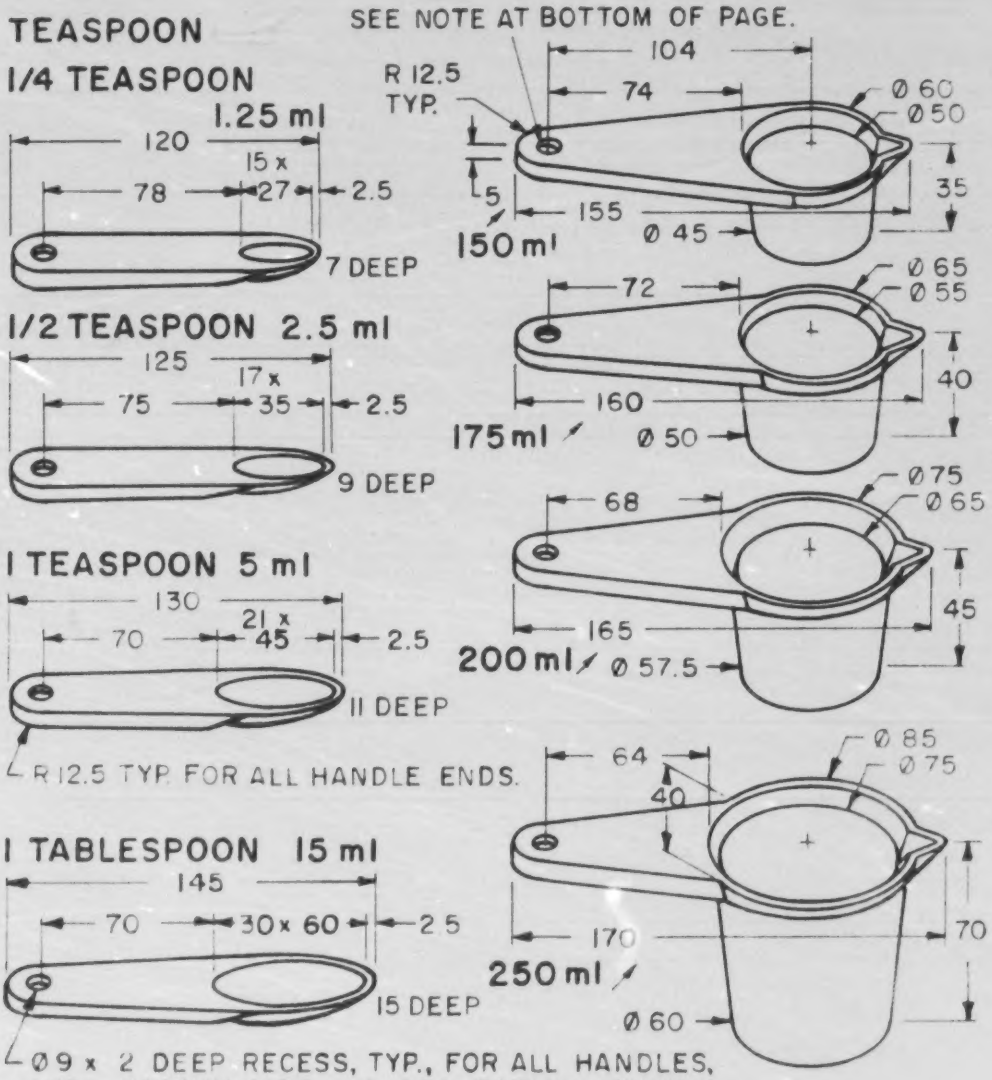
E-5

ALL HANDLES ARE SIMILAR IN SIZE AND SHAPE.

SCALE 1:1

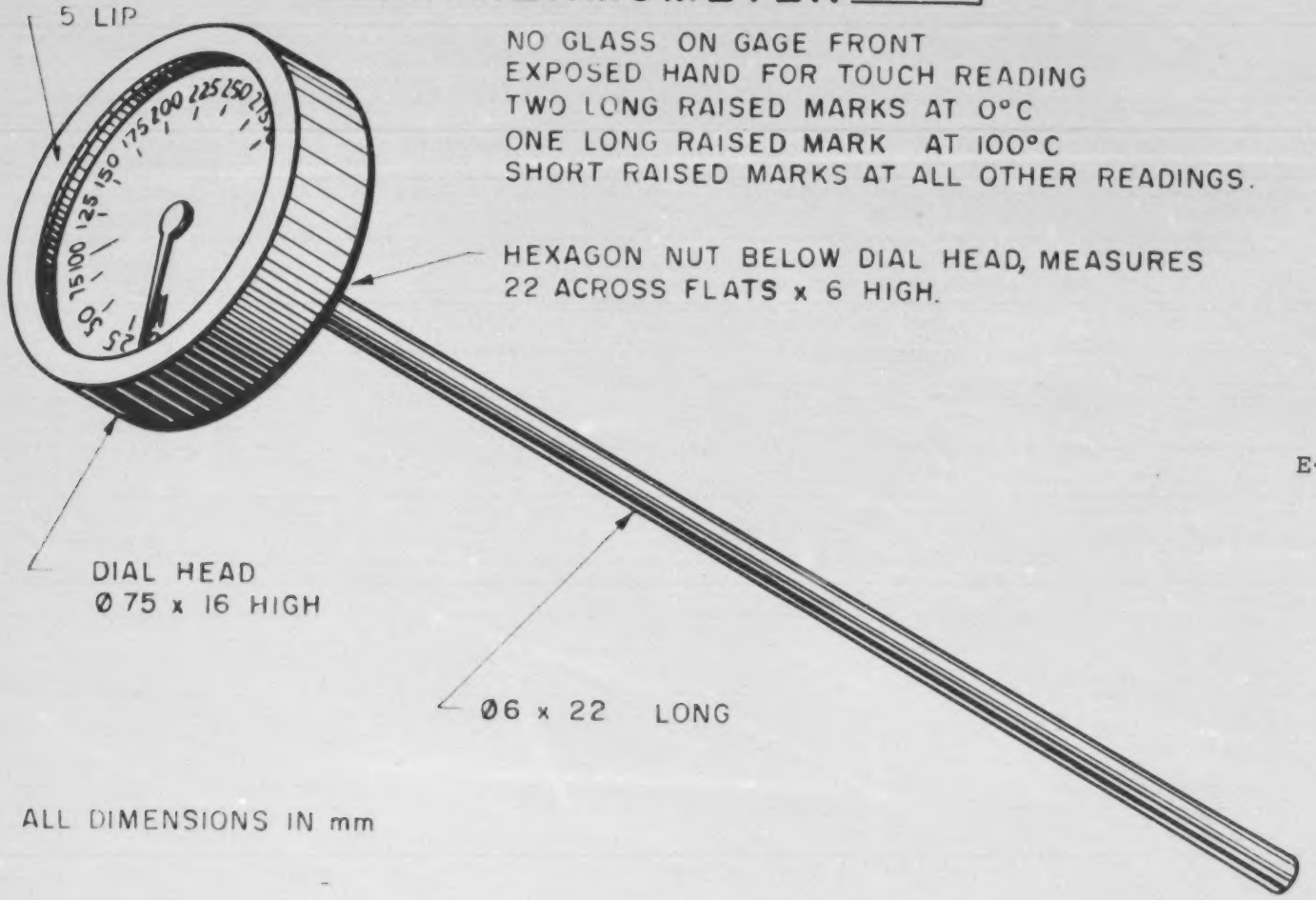
SPOON AND CUP MEASURING SET

MATCHING SPOON AND CUP MEASURING SET WHICH SNAPS TOGETHER. ALL PIECES FIT IN SIZE SEQUENCE FROM 1/4 [1.25 ml] SPOON TO 1 CUP [250 ml].



ALL DIMENSIONS IN mm. SCALE 1: 2

THERMOMETER



NO GLASS ON GAGE FRONT
EXPOSED HAND FOR TOUCH READING
TWO LONG RAISED MARKS AT 0°C
ONE LONG RAISED MARK AT 100°C
SHORT RAISED MARKS AT ALL OTHER READINGS.

HEXAGON NUT BELOW DIAL HEAD, MEASURES
22 ACROSS FLATS x 6 HIGH.

E-7

ALL DIMENSIONS IN mm

120

HANDBOOK FOR TEACHING METRICS TO THE SIGHT HANDICAPPED

Metric Conversion in Vocational Education
Grant No. OEG-0-74-1661
Project No. V0151VZ

Developed By
The Center for Metric Education
Western Michigan University
Kalamazoo, Michigan

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The materials included in this handbook are designed for the teacher or monitor who will be overseeing the learning activities for persons with sight handicaps. The activities included in these three lessons were designed to teach basic fundamentals of the SI metric measuring system and their application to metric measuring devices.

Included in this handbook is a four-page folder, which provides a brief history of the measuring system and a multi-color chart entitled, THE MODERNIZED METRIC SYSTEM. Figure 1. It is recommended that you study these materials so that you might give help to the learner at any point during the lesson.

Note that the SI system consists of three types of units; namely, the base units, of which there are seven; the supplementary units, of which there are two; and the derived units, of which there are many. Of the seven base units three, namely the unit of length, the metre; the unit of mass, the kilogram; and the unit of temperature, the kelvin, are distinct to the SI metric measuring system. The other four units, namely the unit of time, the second; the unit of electrical current, the ampere; the unit of luminous intensity, the candela; and the unit of amount of substance, the mole, are the same in both the metric and the customary (English) system.

For additional information on various aspects of the metric system, it is recommended that you study the folder

entitled, NBS GUIDELINES FOR THE USE OF THE METRIC SYSTEM. Figure 2. This explains technical details of the SI metric measuring system.

Note that in Table 1 the seven base units and the two supplementary units are explained. In Table 2 there is a list of some of the more common derived units with special names. These are the more common technical units that will need to be known by persons who will be using metrics in their work or on the job.

This learning packet will concentrate on three base units; namely the metre, which is the unit of length, the kilogram, which is the unit of mass and weight; and degrees Celsius, which is the unit of temperature used for everyday purposes. The kelvin is used for technical work only. In addition, the derived unit of area, which is the square metre, and the derived unit of volume, which is a cubic metre, are also illustrated. The derived unit for liquid capacity, which is the litre, will be used for all liquid measurements.

The metric system is based on units of ten, much like our money system. Figure 3. The same prefixes are used for all units. Figure 4. For example, the base unit of length is the metre. One thousand times the base unit is the kilometre and one thousandth of the base unit is a millimetre. The millimetre is the unit of length used in all industrial and technical work. The centimetre, which is one hundredth of a metre, is the unit of length used for body measurements and

clothing sizes. The same prefixes are used for all other units. For example, the unit of fluid volume or liquid capacity, the base unit is the litre, one thousand times the base unit is the kilolitre and one thousandth of a litre is the millilitre.

The materials included in this learning unit are divided into three groups as follows:

Station X includes all the learning activities dealing with the unit of length--the metre and the derived unit of area--the square metre. Figure 5.

Station Y includes all the learning activities dealing with the unit of mass (weight)--the kilogram and the unit of volume--the cubic metre. Figure 6.

Station Z deals with all the common units used in the home. Figure 7.

There is a drawing for each of the stations, which shows the arrangement of the learning units, the learner and the cassette player. Note that the tables should be approximately 760 by 1520 millimetres (30 by 60 inches).

To repeat, Station X consists of all the learning units dealing with length--the metre and area--the square metre. There are eleven length units in this learning kit. These should be arranged on the left side of the table so that the learner then sits just to the right of these units with the cassette player directly in front of him. The two units of area should be to the right of the learner. Arrange the

items so that A1 is at the lowest part of the table or just in front of the learner. As each item is used, ask the learner to place it aside before picking up the next item. The learner can either place the item in the upper right-hand corner of the table or on the floor beside him.

In arranging the table make sure that the braille label on each item is on the left side. The tape has been recorded so that there is a thirty second pause after the learner is asked to pick up each item beginning with A1. This will enable the individual to locate the braille markings on the end of the unit and have time to get the item in proper position before the information is given. After the instructions have been given the learner is asked to stop the tape and take as much time as he needs to examine the item before he puts it aside and proceeds to the next item.

After the learner has completed A1 through A11, the individual should then use items B1 and B2. B1 is a comparative unit, which shows the comparison between one square decimetre and four inches square. B2 allows the individual to learn what a square decimetre is and to use the ten square decimetres to make an area one decimetre wide and ten decimetres or one metre long.

After the individual has completed the material at Station X, the learner will move the cassette player to Station Y, at which he will find all the material on mass and volume. Note that these items are arranged from left to right.

Station Y contains the materials marked C and D.

The materials marked C deal with the unit of mass (weight). In the metric system the unit of mass is the kilogram. While the proper term is mass, most people in everyday life will continue to call this weight. The base unit of mass is the kilogram and is the only unit that has a prefix as part of the base unit. Therefore, a thousand times the kilogram, which is the megagram, in everyday life is called the metric ton. One thousandth of a kilogram is the gram. This is the unit that will be used for everyday measuring items.

For example, a pound of butter is approximately 454 grams. The individual using the material marked C will need to spend plenty of time to actually do the weighing activities. At the end of each weighing experience there will be a note which says stop the tape. Then the individual can use as much time as necessary to do the actual weighing before starting the tape again.

D1 is an item that shows that the SI metric system is coherent; that is that there is a direct relationship between length, area, volume and mass. The cubic decimetre is divided into ten centimetres along each edge. Each surface is divided into square centimetres. There are one hundred square centimetres in a square decimetre. D1 weighs or has a mass of one kilogram, which is the same as if it were a container filled with water. One cubic decimetre of water

is called one litre and weighs approximately one kilogram.

Station Z includes several metric activities that are common to the household. These items should be arranged as shown in Figure 7. Make sure that the litre container is filled with water. The learner is to place the glass cup inside the tray to establish a consistent point of reference. The learner should place the index finger of his left hand in the spout. Then place the smallest displacement disc inside the glass cup. Then fill the container with liquid until it just touches the finger. When the displacement disc is removed, there will be two hundred millilitres of water in the cup. Have the learner replace the liquid in the container of water before the individual proceeds to the next activity.

For more detailed information about the metric system, it is recommended that you obtain copies of the reference material listed in the folder, NBS GUIDELINES FOR USE OF THE METRIC SYSTEM.

and 19th centuries, the English system of weights and measures was spread to and established in many parts of the world, including the American colonies.

However, standards still differed to an extent undesirable for commerce among the 13 colonies. The need for greater uniformity led to clauses in the Articles of Confederation (ratified by the original colonies in 1781) and the Constitution of the United States (ratified in 1790) giving power to the Congress to fix uniform standards for weights and measures. Today, standards supplied to all the States by the National Bureau of Standards assure uniformity throughout the country.

The Metric System

The need for a single worldwide coordinated measurement system was recognized over 300 years ago. Gabriel Mouton, Vicar of St. Paul in Lyons, proposed in 1670 a comprehensive decimal measurement system based on the length of one minute of arc of a great circle of the earth. In 1671 Jean Picard, a French astronomer, proposed the length of a pendulum beating seconds as the unit of length. (Such a pendulum would have been fairly easily reproducible, thus facilitating the widespread distribution of uniform standards.) Other proposals were made, but over a century elapsed before any action was taken.

In 1790, in the midst of the French Revolution, the National Assembly of France requested the French Academy of Sciences to "deduce an invariable standard for all the measures and all the weights." The Commission appointed by the Academy created a system that was, at once, simple and scientific. The unit of length was to be a portion of the earth's circumference. Measures for capacity (volume) and mass (weight) were to be derived from the unit of length, thus relating the basic units of the system to each other and to nature. Furthermore, the larger and smaller versions of each unit were to be created by multiplying or dividing the basic units by 10 and its multiples. This feature provided a great convenience to users of the system, by eliminating the need for such calculations as dividing by 16 (to convert ounces to pounds) or by 12 (to convert inches to feet). Similar calculations in the metric system could be performed simply by shifting the decimal point. Thus the metric system is a "base-10" or "decimal" system.

The Commission assigned the name *metre* (which we also spell meter) to the unit of length. This name was derived from the Greek word *metron*, meaning "a measure." The physical standard representing the meter was to be constructed so that it would equal one ten-millionth of the distance from the north pole to the equator along the meridian of the earth running near Dunkirk in France and Barcelona in Spain.

The metric unit of mass, called the "gram," was defined as the mass of one cubic centimeter (a cube that is 1/100 of a meter on each side) of water at its temperature of maximum density. The cubic decimeter (a cube 1/10 of a meter on each side) was chosen as the unit of fluid capacity. This measure was given the name "liter."

Although the metric system was not accepted with enthusiasm at first, adoption by other nations occurred steadily after France made its use compulsory in 1840. The standardized character and decimal features of the metric system made it well suited to scientific and engineering work. Consequently, it is not surprising that the rapid spread of the system coincided with an age of rapid technological development. In the United States, by Act of Congress in 1866, it was made "lawful throughout the United States of America to employ the weights and measures of the metric system in all contracts, dealings or court proceedings."

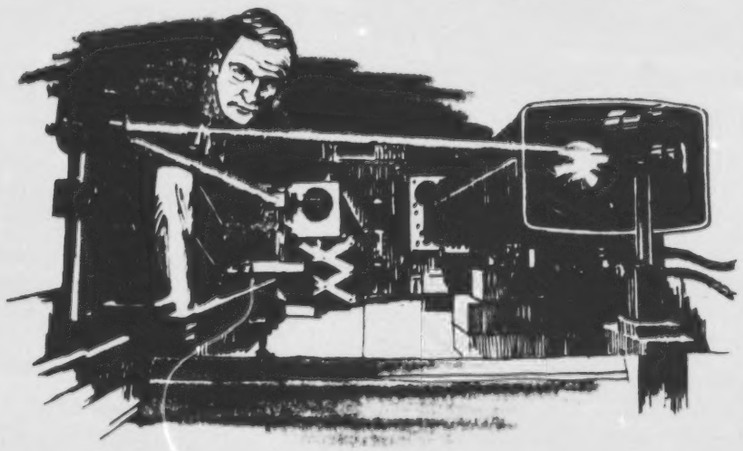
By the late 1860's, even better metric standards were needed to keep pace with scientific advances. In 1875, an international treaty, the "Treaty of the Meter," set up well-defined metric standards for length and mass, and established permanent machinery to recommend and adopt further refinements in the metric system. This treaty, known as the Metric Convention, was signed by 17 countries, including the United States.

As a result of the Treaty, metric standards were constructed and distributed to each nation that ratified the Convention. Since 1893, the internationally agreed-to metric standards have served as the fundamental weights and measures standards of the United States.

By 1900 a total of 35 nations—including the major nations of continental Europe and most of South America—had officially accepted the metric system. Today, with the exception of the United States and a few small countries, the entire world is using predominantly the metric system or is committed to such use. In 1971 the Secretary of Commerce, in transmitting to Congress the results of a 3-year study authorized by the Metric Study Act of 1968, recommended that the U.S. change to predominant use of the metric system through a coordinated national program. The Congress is now considering this recommendation.

The International Bureau of Weights and Measures located at Sevres, France, serves as a permanent secretariat for the Metric Convention, coordinating the exchange of information about the use and refinement of the metric system. As measurement science develops more precise and easily reproducible ways of defining the measurement units, the General Conference of Weights and Measures—the diplomatic organization made up of adherents to the Convention—meets periodically to ratify improvements in the system and the standards.

In 1960, the General Conference adopted an extensive revision and simplification of the system. The name *Le Système International d'Unités* (International System of Units), with the international abbreviation SI, was adopted for this modernized metric system. Further improvements in and additions to SI were made by the General Conference in 1964, 1968, and 1971.



UNITED STATES DEPARTMENT OF COMMERCE
FREDERICK B. DENT, Secretary
NATIONAL BUREAU OF STANDARDS / RICHARD W. ROBERTS, Director

Special Publication 304 A. Reissued September, 1974

Figure 1

Brief History of

MEASUREMENT SYSTEMS

with a Chart of the Modernized Metric System

"Weights and measures may be ranked among the necessaries of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property; to every transaction of trade and commerce; to the labors of the husbandman; to the ingenuity of the artificer; to the studies of the philosopher; to the researches of the antiquarian, to the navigation of the mariner, and the marches of the soldier; to all the exchanges of peace, and all the operations of war. The knowledge of them, as in established use, is among the first elements of education, and is often learned by those who learn nothing else, not even to read and write. This knowledge is riveted in the memory by the habitual application of it to the employments of men throughout life."

JOHN QUINCY ADAMS
Report to the Congress, 1821

Weights and measures were among the earliest tools invented by man. Primitive societies needed rudimentary measures for many tasks: constructing dwellings of an appropriate size and shape, fashioning clothing, or bartering food or raw materials.

Man understandably turned first to parts of his body and his natural surroundings for measuring instruments. Early Babylonian and Egyptian records and the Bible indicate that length was first measured with the forearm, hand, or finger and that time was measured by the periods of the sun, moon, and other heavenly bodies. When it was necessary to compare the capacities of containers such as gourds or clay or metal vessels, they were filled with plant seeds which were then counted to measure the volumes. When means for weighing were invented, seeds and stones served as standards. For instance, the "carat," still used as a unit for gems, was derived from the carob seed.

As societies evolved, weights and measures became more complex. The invention of numbering systems and the science of mathematics made it possible to create whole systems of weights and measures suited to trade and commerce, land division, taxation, or scientific research. For these more sophisticated uses it was necessary not only to weigh and measure more complex things—it was also necessary to do it accurately time after time and in different places. However, with limited international exchange of goods and communication of ideas, it is not surprising that different systems for the same purpose developed and became established in different parts of the world—even in different parts of a single continent.

The English System

The measurement system commonly used in the United States today is nearly the same as that brought by the colonists from England. These measures had their origins in a variety of cultures—Babylonian, Egyptian, Roman, Anglo-Saxon, and Norman French. The ancient "digit," "palm," "span," and "cubit" units evolved into the "inch," "foot," and "yard" through a complicated transformation not yet fully understood.

Roman contributions include the use of the number 12 as a base (our foot is divided into 12 inches) and words from which we derive many of our present weights and measures names. For example, the 12 divisions of the Roman "pes," or foot, were called *unciae*. Our words "inch" and "ounce" are both derived from that Latin word.

The "yard" as a measure of length can be traced back to the early Saxon kings. They wore a sash or girdle around the waist—that could be removed and used as a convenient measuring device. Thus the word "yard" comes from the Saxon word "gird" meaning the circumference of a person's waist.

Standardization of the various units and their combinations into a loosely related system of weights and measures sometimes occurred in fascinating ways. Tradition holds that King Henry I decreed that the yard should be the distance from the tip of his nose to the end of his thumb. The length of a furlong (or furrow-long) was established by early Tudor rulers as 220 yards. This led Queen Elizabeth I to declare, in the 16th century, that henceforth the traditional Roman mile of 5,000 feet would be replaced by one of 5,280 feet, making the mile exactly 8 furlongs and providing a convenient relationship between two previously ill-related measures.

Thus, through royal edicts, England by the 18th century had achieved a greater degree of standardization than the continental countries. The English units were well suited to commerce and trade because they had been developed and refined to meet commercial needs. Through colonization and dominance of world commerce during the 17th, 18th,

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Stock No. 0303-01073

THE MODERNIZED

metric system

The International System of Units-SI

is a modernized version of the metric system established by international agreement. It provides a logical and interconnected framework for all measurements in science, industry, and commerce. Officially abbreviated SI, the system is built upon a foundation of seven base units, plus two supplementary units, which appear on this chart along with their definitions. All other SI units are derived from these units. Multiples and submultiples are expressed in a decimal system. Use of metric weights and measures was legalized in the United States in 1866, and since 1893 the yard and pound have been defined in terms of the meter and the kilogram. The base units for time, electric current, amount of substance, and luminous intensity are the same in both the customary and metric systems.

SEVEN BASE UNITS

meter-m

kilogram-kg

second-s

ampere-A

kelvin-K

mole-mol

candela-cd

TWO SUPPLEMENTARY UNITS

radian-rad

steradian-sr

A full-scale wall chart, NBS Special Publication 304 (Revised October 1972,) is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

NBS GUIDELINES FOR USE OF THE METRIC SYSTEM

LC1056
November 1974

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

Figure 2

The policy of the National Bureau of Standards is to encourage and lead in national use of the metric system, formally called the International System of Units (SI). The NBS guidelines are intended to aid and expedite the transition from the use of non-SI to SI units in Bureau issuances, publications, and reports; they are to be implemented logically and equitably.

NBS practice is to use SI units in the publication of all descriptive and essential data (as deunited below). SI units should be used by the NBS staff in both technical and non-technical publications and addresses. Exceptions are allowed when the intended audience would not comprehend such units. Until the national use of SI units prevails, exceptions to exclusive usage of SI units may be required in some NBS publications. The general rule is that exceptions must be determined by considering the audience for a given publication. If the readership would be limited by the exclusive use of SI units, customary units may be added in parentheses for scientific and technical publications as well as in press releases and issuances to the general public. The emphasis should be not only on communicating the contents, but also on familiarizing readers with the metric system. In public and technical presentations the NBS staff should aid the audience in thinking metric; speakers should acquaint the audience with SI units if these units are not ordinarily used by the listeners. Exceptions to the exclusive use of SI units should be used to educate both technical and non-technical audiences in SI units and their use. An exception should not be invoked as a precedent for prolonging the use of non-SI units.

For over ten years, NBS has followed an internal policy of using the International System of Units (SI) in our formal publications. This new set of guidelines reaffirms, clarifies, and strengthens this policy. It now encourages the fullest possible conformity to SI in all of our publications and in all of our dealings with the science and engineering communities. Furthermore, in our dealings with the public, metric units should be used along with customary units in order to help educate all people in the use of metric units of measurement.

I urge all of you to keep these guidelines handy and to use SI to the fullest possible extent. If you need further help or further information on SI, call on your appropriate Editorial Review Board or on our NBS metric information office, whose staff is available and anxious to assist in uniform and correct SI usage.

Richard W. Roberts
Director

The transition period to the predominant national use of the metric system is not sharply defined. NBS leadership in this national adoption of SI units will be more effective if the transition within NBS is as complete and as rapid as possible. The staff is urged to remember this fact in the preparation of all NBS presentations and publications.

All numerical data, both descriptive and essential, are affected by this policy.

Descriptive data describe arrangements, environments, noncritical dimensions and shapes of apparatus, and similar measurements not affecting calculations or results. Such data should be expressed in SI units unless this makes the expression excessively complicated. For example, commercial gauge designations, commonly used items identified by nominal dimensions, or other commercial nomenclatures (such as drill sizes, or standards for weights and measures) expressed in customary units are acceptable.

Essential data express, precede, or interpret the quantitative results being reported. All such data should be expressed solely in SI units except in those fields where (a) the sole use of SI units would create a serious impediment to communications, or (b) SI units have not been specified. Exceptions may also occur when dealing with commercial devices, standards, or units having some legal definition, such as commercial weights and measures. Even in such instances, SI units should be used when practical and meaningful; for example, this may be done by adding non-SI units in parentheses after SI units. In tables, SI and customary units may be shown in parallel columns. In graphs, a secondary set of coordinate markings in non-SI units may also be included. The top and right hand sides of a graph are often appropriate for this purpose.

The Metric System: SI

The SI is constructed from seven base units for independent quantities, plus two supplementary units for plane angle and solid angle. (See Table 1.) Units for all other quantities are derived from these nine units. In Table 2 are listed 15 SI derived units with special names which were derived from the base and supplementary units in a coherent manner.

which means in brief, that they are expressed as products and ratios of the nine base and supplementary units without numerical factors. All other SI-derived units, such as those in tables 3 and 4, are similarly derived in a coherent manner from the 21 base, supplementary, and special-name SI units. For use with the SI units there is a set of 14 prefixes (see table 5) to form multiples and sub-multiples of these units.

The SI units together with the 14 prefixes provide a logical and interconnected framework for measurements in science, industry, and commerce. Along with leading national and international professional and standardizing bodies, NBS encourages familiarity with, and diffusion of, SI units throughout all sectors of United States activities.

Fundamental Constants Natural Units

In some cases quantities are commonly expressed in terms of fundamental constants of nature, and the use of these constants or "natural units" is acceptable. The author, however, should state clearly which natural units are being used. Such broad terms as "atomic units" should be avoided when there is danger of confusion. Typical examples of natural units are:

Unit	Symbol
elementary charge	e
electron mass	m_e
proton mass	m_p
Bohr radius	a_0
electron radius	r_e
Compton wavelength of electron	λ_C
Bohr magneton	μ_B
nuclear magneton	μ_N
speed of light	c
Planck constant	h

For additional examples, see "Fundamental Constants," *Dimensions/NBS*, Jan. 1973.

Units Acceptable for Use with SI

Certain units which are not part of the SI are used so widely that it is impractical to abandon them. The units that are accepted by NBS for continued use with the International System are listed in table 6. In those cases where their use is already well established, the International Committee of Weights and Measures (CIPM) has authorized ("accepted for use") their use in the following common units:

nautical mile	hectare	gal
knot	liter	curie
angstrom	bar	roentgen
standard atmosphere	are	rad

The short names for compound units (such as "coulomb" for "ampere-second" and "pascal" for "newton per square meter") exist for convenience, and either form is correct (see table 2). For example, communication sometimes is facilitated if the author expresses magnetic flux in the compound form volt-seconds instead of using the synonym, webers, because of the descriptive value implicit in the compound phrase.

In some specialized fields, such as magnetism in material media, the appropriate quantities are still to be determined. Guidelines for these cases are flexible. Use of a table of conversion may be misleading, and it may even be preferred to compare different physical quantities in different systems of units.

Special Considerations

It is acceptable to use the Celsius temperature (symbol t) defined by

$$t = T - T_0$$

where T is the thermodynamic temperature, expressed in kelvins, and $T_0 = 273.15$ K by definition. The unit "degree Celsius" is thus equal to the unit "kelvin" when used as an interval or difference of temperature. Celsius temperature is expressed in degrees Celsius (symbol °C).

In situations where the use of the symbol K for thermodynamic temperature would lead to confusion with other symbols, it may be replaced by °K.

Logarithmic measures such as pH, dB, and Np are acceptable.

On recommendation of the International Committee of Weights and Measures (CIPM), the names of multiples and submultiples of the kilogram are formed by adding prefixes to the word gram.

Words and symbols should not be mixed. If mathematical operations are indicated, for example, only symbols should be used. Any of the forms: newton per meter squared, newton/meter^2, or N/m^2 are acceptable. [illegible] should be used [illegible] and [illegible] periods for abbreviations.

In keeping with the practice of various international bodies and many domestic professional societies, NBS recommends, but does not require, the use of the spelling "meter" for the unit and "metric" for the instrument or all its communications. The ultimate goal is to obtain agreement throughout the world. Regardless of these or other conventions, "liter" and "litre."

Over the years, the term "weight" has been used to designate both quantities: mass and force. The NBS staff is encouraged to follow the practice recommended by the Metric Practice Committee of the American National Metric Council for incorporation in the forthcoming Primary American National Standard "Metric Practice Guide." See Appendix B.

Implementation

NBS policy for the use of SI units in public documents is explicit. The staff is urged to aid in the implementation to the fullest degree practicable. Although the Bureau recognizes the necessity for a transitional period of education and adjustment, these guidelines are designed to place greater emphasis on the use of SI than before.

The provisions of this document are a part of the editorial approval criteria for all NBS writings undergoing review by division and Bureau editorial review boards. In addition, NBS staff members are urged to aid in the diffusion of the knowledge of SI units through all modes of communication including talks, correspondence, etc.

For additional information on the use of SI units, the NBS staff should obtain and use the following publications which are available in the NBS storeroom:

- NBS SP330, 1974 Edition, "The International System of Units."
- ISO, International Standard 1000 (1973 Edition), "SI Units and Recommendations for the Use of Their Multiples."
- E380-72, ASTM, "Metric Practice Guide" (American National Standard Z210.1).

Examples of conversion of non-SI units to SI are given in table 7.

Appendix 1
Units and Conversion Factors

TABLE 1

Quantity	Name	Symbol
SI base units		
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd
SI supplementary units		
plane angle	radian	rad
solid angle	steradian	sr

*Celsius temperature is defined in the text

TABLE 2
SI derived units with special names

Quantity	SI unit			
	Name	Symbol	Expression in terms of other units	Expression in terms of SI base units
frequency	hertz	Hz		s^{-1}
force	newton	N		$m \cdot kg \cdot s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
energy, work, quantity of heat	joule	J	N·m	$m^2 \cdot kg \cdot s^{-2}$
power, radiant flux	watt	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
quantity of electricity, electric charge	coulomb	C	A·s	s·A
electric potential, potential difference, electromotive force	volt	V	W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
capacitance	farad	F	C/V	$m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$
electric resistance	ohm	Ω	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$
conductance	siemens	S	A/V	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$
magnetic flux	weber	Wb	V·s	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$
magnetic flux density	tesla	T	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$
inductance	henry	H	Wb/A	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$
luminous flux	lumen	lm		cd·sr (*)
illuminance	lux	lx		$m^{-2} \cdot cd \cdot sr$ (*)

(*) In this expression the steradian (sr) is treated as a base unit

TABLE 3
Examples of SI derived units expressed in terms of base units

Quantity	SI unit	Unit Symbol
area	square metre	m^2
volume	cubic metre	m^3
speed, velocity	metre per second	m/s
acceleration	metre per second squared	m/s^2
wave number	1 per metre	m^{-1}
density, mass density	kilogram per cubic metre	kg/m^3
current density	ampere per square metre	A/m^2
magnetic field strength	ampere per metre	A/m
concentration (of amount of substance)	mole per cubic metre	mol/m^3
activity (radioactive)	1 per second	s^{-1}
specific volume	cubic metre per kilogram	m^3/kg
luminance	candela per square metre	cd/m^2

TABLE 4
Examples of SI derived units expressed by means of special names

Quantity	SI units		
	Name	Symbol	Expression in terms of SI base units
dynamic viscosity	pascal second	Pa·s	$m^{-1} \cdot kg \cdot s^{-1}$
moment of force	metre newton	N·m	$m^2 \cdot kg \cdot s^{-2}$
surface tension	newton per metre	N/m	$kg \cdot s^{-2}$
heat flux density, irradiance	watt per square metre	W/m^2	$kg \cdot s^{-3}$
heat capacity, entropy	joule per kelvin	J/K	$m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$
specific heat capacity, specific entropy	joule per kilogram kelvin	J/(kg·K)	$m^2 \cdot s^{-2} \cdot K^{-1}$
specific energy	joule per kilogram	J/kg	$m^2 \cdot s^{-2}$
thermal conductivity	watt per metre kelvin	W/(m·K)	$m \cdot kg \cdot s^{-3} \cdot K^{-1}$
energy density	joule per cubic metre	J/m^3	$m^{-1} \cdot kg \cdot s^{-2}$
electric field strength	volt per metre	V/m	$m \cdot kg \cdot s^{-3} \cdot A^{-1}$
electric charge density	coulomb per cubic metre	C/m^3	$m^{-3} \cdot s \cdot A$
electric flux density	coulomb per square metre	C/m^2	$m^{-2} \cdot s \cdot A$
permittivity	farad per metre	F/m	$m^{-3} \cdot kg^{-1} \cdot s^4 \cdot A^2$
permeability	henry per metre	H/m	$m \cdot kg \cdot s^{-2} \cdot A^{-2}$
molar energy	joule per mole	J/mol	$m^2 \cdot kg \cdot s^{-2} \cdot mol^{-1}$
molar entropy, molar heat capacity	joule per mole kelvin	J/(mol·K)	$m^2 \cdot kg \cdot s^{-2} \cdot K^{-1} \cdot mol^{-1}$

TABLE 5
SI prefixes

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{12}	tera	T	10^{-1}	deci	d
10^{9}	giga	G	10^{-2}	centi	c
10^{6}	mega	M	10^{-3}	milli	m
10^{3}	kilo	k	10^{-6}	micro	μ
10^{2}	hecto	h	10^{-9}	nano	n
10^{1}	deka	da	10^{-12}	pico	p
			10^{-15}	femto	f
			10^{-18}	atto	a

TABLE 6
Units in use with the International System

Name	Symbol	Value in SI unit
minute	min	1 min = 60 s
hour	h	1 h = 60 min = 3 600 s
day	d	1 d = 24 h = 86 400 s
degree	°	1° = (π/180) rad
minute	′	1′ = (1/60)° = (π/10 800) rad
second	″	1″ = (1/60)′ = π/648 000) rad
litre or liter	l	1 l = 1 dm^3 = 10^{-3} m^3
tonne (metric ton)	t	1 t = 10^3 kg

TABLE 7

Examples of conversion factors from non SI units to SI

Physical Quantity	Name of Unit	Symbol for Unit	Definition of Unit
length	inch	in	2.54×10^{-2} m
mass	pound (avoirdupois)	lb	0.453 592 37 kg
force	kilogram-force	kgf	9.806 65 N
pressure	atmosphere*	atm	101 325 $N \cdot m^{-2}$
pressure	torr	Torr	(101 325/760) $N \cdot m^{-2}$
pressure	conventional millimetre of mercury	mmHg	$13.5951 \times 980.665 \times 10^{-2}$ $N \cdot m^{-2}$
energy	British Thermal Unit	BTU	1055.06 J
energy	kilowatt-hour	kWh	3.6×10^{6} J
energy	thermochemical calorie	cal_{th}	4.184 J
energy	I.T. calorie	cal_{IT}	4.1868 J
activity (radioactive nuclides)	curie*	Ci	3.7×10^{10} s^{-1}
exposure (x or γ rays)	röntgen*	R	2.58×10^{-4} $C \cdot kg^{-1}$

* The CIPM has sanctioned the use of these units for a limited period of time.

Appendix 2
Writing Style Guides

1. CAPITALS

Units: When written in full, the names of all units start with a lower case letter, except at the beginning of a sentence. Note that in degree Celsius the unit "degree" is lower case but the modifier "Celsius" is capitalized. The "degree centigrade" is obsolete.

Symbols: Unit symbols are written with lower case letters except that the first letter is upper case when the name of the unit is derived from the name of a person.

Prefixes: Except for tera (T), giga (G), and mega (M), all symbols for numerical prefixes are written with lower case letters. All prefixes are written in lower case letters when written out in full, except where the entire unit name is written in upper case letters.

2. PLURALS

a. When written in full, the names of units are made plural when appropriate. Fractions (both common and decimal) are always singular.

b. Symbols for units are the same in singular and plural (no "s" is ever added to indicate a plural).

3. PERIODS

A period is NOT used after a symbol, except at the end of a sentence.

4. THE DECIMAL POINT

The dot is used as the decimal point and is placed on the line. When writing numbers less than one, a zero must be written before the decimal point.

5. GROUPING OF DIGITS

a. Separate digits into groups of three, counting from the decimal sign. The comma should not be used. Instead, a space is left to avoid confusion, since many countries use a comma for the decimal point.

b. In numbers of four digits, the space is not recommended, unless four-digit numbers are grouped in a column with numbers of five digits or more.

6. SPACING

a. When writing symbols or names for units having prefixes, *no* space is left between letters making up the symbol or the name.

b. When writing a symbol after a number to which it refers, a space must be left between the number and the symbol (except for degree, minute, and second of angle).

7. COMPOUND UNITS

When writing the symbol for a compound unit that is formed by the multiplication of two or more units, a centered dot is used. For example N•m.

When writing the name for such a unit, a hyphen is recommended for a space is permissible) but never a centered dot. For example, newton-metre or newton metre.

Appendix 3
Excerpts from the Forthcoming ANS Metric Practice Guide

The principal departure of SI from the gravimetric form of metric engineering units is the separate and distinct units for mass and force. The kilogram is restricted to the unit of mass. The newton is the unit of force and should be used in place of kilogram-force. Likewise, the newton instead of kilogram-force should be used in combination units which include force, for example, pressure or stress ($N/m^2 = Pa$), energy ($N \cdot m = J$), and power ($N \cdot m/s = W$).

Considerable confusion exists in the use of the term weight as a quantity to mean either force or mass. In commercial and everyday use, the term weight nearly always means mass; thus, when one speaks of a person's weight, the quantity referred to is mass. This non-technical use of the term weight in everyday life will probably persist. In science and technology, the term weight of a body has usually meant the force that if applied to the body would give it an acceleration equal to the local acceleration of free fall. The adjective "local" in the phrase "local acceleration of free fall" has usually meant a location on the surface of the earth; in this context the "local acceleration of free fall" has the symbol *g* (sometimes referred to as "acceleration of gravity") with observed values of *g* differing by over 0.5 percent at various points on the earth's surface. The use of "force of gravity" (*mg* = mass times the acceleration of gravity) in lieu of "weight" with this meaning is recommended. Because of the dual use of the term weight as a quantity, this term should be avoided in technical practice except under circumstances in which its meaning is completely clear. When the term is used, it is important to know whether mass or force is intended, and to use SI units properly as described above by using kilograms for mass or newtons for force.

Figure 3

YOUR MONEY AND METRIC LENGTH

YOUR MONEY	METRIC LENGTH	SYMBOL	NUMBER OF METRES
$1,000.00	kilometre	km	1 000.
$100.00	hectometre	hm	100.
$10.00	dekametre	dam	10.
$1.00	metre	m	1.
DIME ○	decimetre	dm	0.1
CENT ○	centimetre	cm	0.01
MILL ○	millimetre	mm	0.001

Figure 4

PREFIXES, EXPONENTS, and SYMBOLS

Decimal Form	Exponent or Power	Prefix	Pronunciation	Symbol	Meaning
1 000 000 000 000	$= 10^{12}$	tera	tĕr′ ȧ	T	trillion
1 000 000 000	$= 10^{9}$	giga	ǰi′ gȧ	G	billion
1 000 000	$= 10^{6}$	mega	mĕg′ ȧ	M	million
1 000	$= 10^{3}$	kilo	kĭl′ ō	k	thousand
100	$= 10^{2}$	hecto	hĕk′ tō	h	hundred
10	$= 10^{1}$	deka	dĕk′ ȧ	da	ten
1					base unit
0.1	$= 10^{-1}$	deci	dĕs′ ĭ	d	tenth
0.01	$= 10^{-2}$	centi	sĕn′ tĭ	c	hundredth
0.001	$= 10^{-3}$	milli	mĭl′ ĭ	m	thousandth
0.000 001	$= 10^{-6}$	micro	mī′ krō	μ	millionth
0.000 000 001	$= 10^{-9}$	nano	năn′ ō	n	billionth
0.000 000 000 001	$= 10^{-12}$	pico	pēc ō	p	trillionth
0.000 000 000 000 001	$= 10^{-15}$	femto	fĕm′ tō	f	quadrillionth
0.000 000 000 000 000 001	$= 10^{-18}$	atto	ăt′ tō	a	quintrillionth

most commonly used

TABLE X

LENGTH AND AREA

TABLE AREA APPROXIMATELY 30" X 60" OR 760 mm X 1520 mm

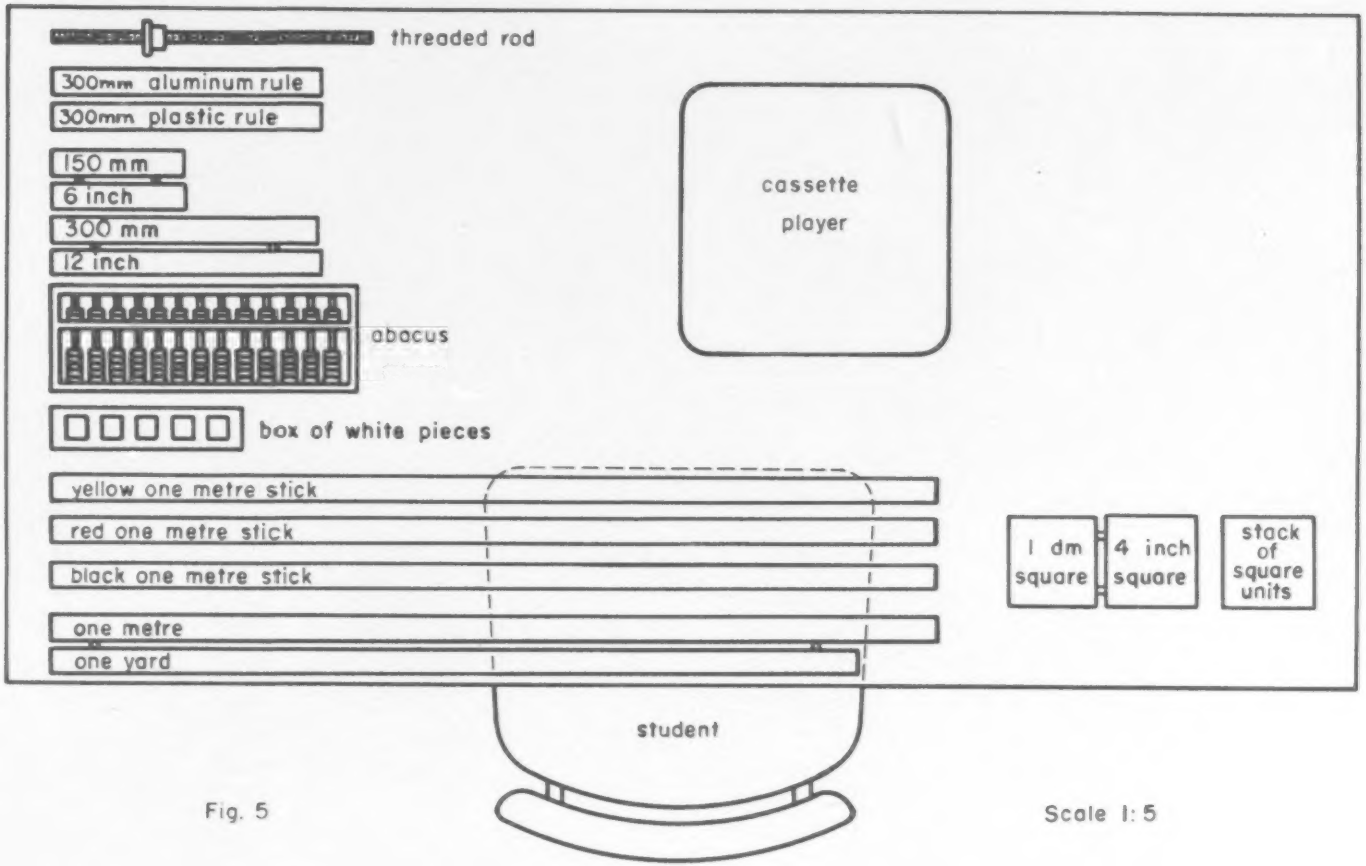

Fig. 5

Scale 1:5

Figure 5

LEARNING THE METRIC SYSTEM FOR
PERSONS WITH SIGHT IMPAIRMENT

STATION X -- LENGTH AND AREA

Measurement is finding the size, quantity and amount of things. People learn to measure using their sense of seeing, hearing, smelling, tasting and touching. You have learned how to measure primarily by touching or examining, and also by hearing, smelling and tasting. Measurement is a system or way of measuring units. For example, we measure how long or short something is, how heavy or light it is, what part of the hour, day or week it is or how hot or cold it is. Any of these things can be measured using a standard. In the United States we have been using a standard called the customary system, or it is sometimes called the English or inch-pound system. It is made up of eighty different, unrelated units, many of which are based on ideas that date back to the earliest civilization.

Now the United States is moving to the metric system, which is used by all other countries in the world. There are many advantages to the metric system including the fact that it is a decimal system based on units of ten like our money. All multiples and submultiples are in simple powers of ten.

If you learn three simple rules of the metric system, you will have enough knowledge to use it in day to day living. The rules are:

1. The prefix "milli" means one thousandth part.
2. The prefix "centi" means one hundredth part.
3. The prefix "kilo" means one thousand times.

When these prefixes are used with metric units, objects can be measured or weighed from the smallest to the largest. For example, a millimetre is one thousandth part of a metre. A centimetre is one hundredth part of a metre and a kilometre is one thousand metres. A millilitre is one thousandth part of a litre, a kilolitre is one thousand litres.

It is easier to learn and easier to remember. There is a direct relationship between the units of length, liquid capacity and weight.

The metric system is the accepted international system

of measurement. The same language is used in mathematics, science, trade, technology and daily living. Over 90% of the world's population uses the metric system and over 80% of world trade is carried on in the metric system.

For practical purposes, the following units are used in everyday life.

1. The metre--the unit of length is slightly longer than a yard (about 39.37 inches).
2. The square metre--the unit of area. A square decimetre is slightly larger than four inches square.
3. The cubic metre--the unit of volume is about 30% larger than a cubic yard. A cubic decimetre is the same as a litre.
4. The kilogram--the unit of weight is a little more than twice a pound (2.2 pounds).
5. The litre--the unit of liquid capacity or volume is a little more than a quart (about 6% more).
6. The unit of temperature--degrees Celsius. In Celsius, water freezes at 0 °C and boils at 100 °C. Normal body temperature is 37 °C.

You will learn about these by using the devices included in this metric activity. The first group of devices will teach you about length and area.

Pick up A1 with the number in your left hand and the other end in your right hand. (THIRTY SECOND PAUSE) The base unit of length in the metric system is the metre, spelled m e t r e. A metre is about equal to the distance from the left side of your face to the outstretched tip of your right hand. In other words, the metre is a little longer than the yard. This is the longest bar that you are now touching. The other lower bar is a yard. Notice the metre is about ten percent longer than the yard. Actually it is 3.37 inches longer.

The shorter unit, which is the yard, is based on human measurements. King Edward II decided that the yard would be the distance from his nose to the end of his outstretched hand. Later he decided to make this into the official measuring unit and had a metal bar made called an iron unla. The longer unit, which is the metre, was first described as one ten millionth of the distance from the North Pole to the Equator on a line running through Paris. Early scientists in France checked out this measurement and found it to be quite accurate. However, later a special metal bar was made that was the official metre length. A number of these bars were produced and the original was kept near Paris, France, and the others were sent to other

countries such as the United States. Now the metre is defined in terms of a wavelength of light.

Now stop the tape. When you are satisfied that you understand this concept, put this item aside and start the tape again.

Pick up A2. (THIRTY SECOND PAUSE) This is a very smooth bar of plastic. It is not graduated and is exactly a metre long. This plastic rod is six millimetres thick and twenty millimetres wide and one thousand millimetres or one metre long.

Now stop the tape. When you are satisfied that you understand this concept, put this item aside and start the tape.

Pick up A3. (THIRTY SECOND PAUSE) If you run your finger along one edge of this bar, you will notice the graduations. This bar is divided into decimetres. Notice that there are ten of these. Ten decimetres equal one metre.

The metric system is a decimal system, like our money, so that the metre is divided into smaller equal parts. Actually we can compare our money and the metre as follows. If a metre equals a dollar, then the metre is divided into ten smaller units called decimetres, just like the dollar is divided into ten smaller units called dimes. The metre is also divided into one hundred smaller units called centimetres, just like the dollar is divided into one hundred small units called cents. The metre is divided into one thousand small units called millimetres, just like the dollar is divided into one thousand small units for tax purposes called mills.

Stop the tape. Proceed when you feel you understand this concept.

Pick up A4. (THIRTY SECOND PAUSE) The third bar is divided into one hundred equal parts; notice these are centimetres. One hundred centimetres equal one metre, ten centimetres equal one decimetre.

Stop the tape. Proceed when you feel you understand this concept.

Pick up A5. (THIRTY SECOND PAUSE) This holder contains a stack of smooth blocks, each of which is a decimetre long. You can lay these end to end and find that they will equal the long smooth bar, which is a metre. Remember again, the metre is divided into ten parts called deci-

metres, spelled d e c i m e t r e s, and it is divided into one hundred small parts called centimetres, spelled c e n t i m e t r e s, and it is divided into one thousand equal parts called millimetres, spelled m i l l i - m e t r e s.

Each of these length measurements have a symbol that is the same throughout the world. The symbol for the metre is a small "m". The symbol for the decimetre is a small "dm". The symbol for the centimetre is "cm" and the symbol for the millimetre is a small "mm". Because they are symbols, not abbreviations, there are no periods at the end of the symbol.

Stop the tape. Proceed again when you feel you have mastered this concept.

Pick up A6. (THIRTY SECOND PAUSE) The millimetre is the unit for all industrial work. It is a small unit, approximately the thickness of a dime. You have in your hands an abacus that is made up of units of one millimetre thickness. Start at the left end and move the one millimetre unit to the left. Remember that each of these are one millimetre thick. Every ten make a centimetre. In other words, there are ten millimetres in one centimetre. Remember that one millimetre is a very small unit. It is about the thickness of a dime. If we compare it to our older system, it is about 1/25th of an inch.

Stop the tape. Proceed again when you feel you have mastered this concept.

Pick up A7. (THIRTY SECOND PAUSE) The top bar is three hundred millimetres long. The bottom bar is one foot long, which is the typical ruler used in the customary system. The three hundred millimetre rule is a common length of rule.

The one foot rule is the rule that has been used in schools for years as the common measuring unit. The one foot is the longer of the two and equals three hundred and five millimetres. Therefore, the three hundred millimetre rule is just slightly shorter or about the thickness of five dimes less.

Stop the tape. Proceed again when you feel you have mastered this concept.

Pick up A8. (THIRTY SECOND PAUSE) The top bar is one hundred fifty millimetres long. The bottom bar is six

inches, the length of a pocket-size ruler. The one hundred fifty millimetre rule is about two and one half millimetres shorter.

Stop the tape. Proceed again when you feel you have mastered this concept.

Pick up A9. (THIRTY SECOND PAUSE) This is an inexpensive rule. One edge is graduated in the metric system and the second edge is marked in the customary system. The smallest graduation or division on the metric edge is five millimetres. There is a longer line, which equals ten millimetres or one centimetre. Every other long line is marked two, four, six and so forth. The two indicates two centimetres, the four is four centimetres, etc. Remember that two centimetres is the same as twenty millimetres; four centimetres is the same as forty millimetres. The ruler is marked up to thirty, which means that the rule is thirty centimetres or three hundred millimetres long.

For everyday use the centimetre can be used for measuring cloth, for body measurements and many other common household items. However, in industry the millimetre is the standard unit. Even the length of a large airplane will be given in millimetres.

Stop the tape. When you feel you have mastered this concept, proceed.

Pick up A10. This unit is labeled on the back. (THIRTY SECOND PAUSE) The very smooth rule with the tapered edge is a precision measuring unit that is thirty centimetres or three hundred millimetres long. Each small division on the tapered edge is two millimetres so that you can count two, four, six, eight. Then there is a longer line, which is marked with a number one, which means one centimetre or ten millimetres. Each of these longer lines marked one, two, three, four, five, six, seven, eight, nine and ten represent centimetre lines. However, for precision measuring they would be referred to as millimetres. For example, if you moved to the one marked four, this would be forty millimetres. The next smallest division beyond that would be forty millimetres plus two or forty-two millimetres.

Stop the tape. When you fully understand this concept, start the tape again.

Pick up A11. (THIRTY SECOND PAUSE) This is a marking gage that consists of a threaded rod with two nuts that

turn. Start by turning the first nut against the pin so that the groove on one end of the pin and the groove on the first nut line up. Move the second nut away from the first nut. Each turn of the first nut equals one millimetre. Ten turns equal ten millimetres or one centimetre. The threaded rod is flattened with a single sharp thread at every ten millimetres or one centimetre location. By turning the nut ten more times you would have two centimetres. The second nut is a lock nut, which can be used to tighten against the first after the correct distance is secured. This unit can be used as a measuring or marking gage.

Stop the tape. When you fully understand this concept, start the tape again.

Let's repeat. Length measurement in the metric system is based on the unit of length called the metre. It is a decimal system with the metre divided into ten equal parts, each of which is a decimetre. When the metre is divided into one hundred equal parts, each of the smaller parts is a centimetre. When the metre is divided into one thousand equal parts, each of the smaller parts is a millimetre.

This concludes the material on length. If you would like to examine any of these items again, stop the tape. Proceed again when you are ready.

Pick up B1. (THIRTY SECOND PAUSE) The smaller square in your hands is equal to one square decimetre or one hundred square centimetres. The symbol for a square decimetre is a lower case "dm" followed by a superior two. The slightly larger square is equal to four inches square. Both squares are one centimetre thick. The symbol for the square centimetre is a lower case "cm" followed by a superior two. A square centimetre would easily fit in a circle equal to a dime.

Stop the tape. When you have had enough time to examine this item, proceed again.

Pick up B2. (THIRTY SECOND PAUSE) The box in your hands now contains ten squares. Each of these squares is one centimetre thick and ten centimetres or one decimetre long on each side. You could say that each square is one decimetre long on each side since one decimetre equals ten centimetres. The area would be equal to one square decimetre or one hundred square centimetres. If you layed these ten blocks out side by side, they would be one decimetre wide and one metre long. If you stack them one on

top of the other, they would be one decimetre on each edge. This stack of squares measuring one decimetre on each edge makes a unit of one cubic decimetre. The symbol for a cubic decimetre is a lower case "dm" followed by a superior three.

In the metric system there is a definite relationship between length, volume, liquid capacity and weight or mass. This particular set of squares is one decimetre long on each edge and one centimetre thick. Ten of them stacked one on top of the other make a cube equal to one cubic decimetre. If this cube were an open container, it would be called a litre. If the cube were filled with water, it would weigh one kilogram. This set of squares does weigh one kilogram or one thousand grams. Each square weighs one hundred grams.

This concludes the learning activities on length and area. After you have stopped the tape, complete the last learning activities in this group. Then rewind the tape, remove it from the cassette player and leave it on the table with the other items at this station.

You will now proceed to Station Y, taking your cassette player with you. When you arrive at Station Y, place the next cassette tape in the cassette player and proceed. Now stop the tape and complete the instructions.

TABLE Y

MASS AND VOLUME

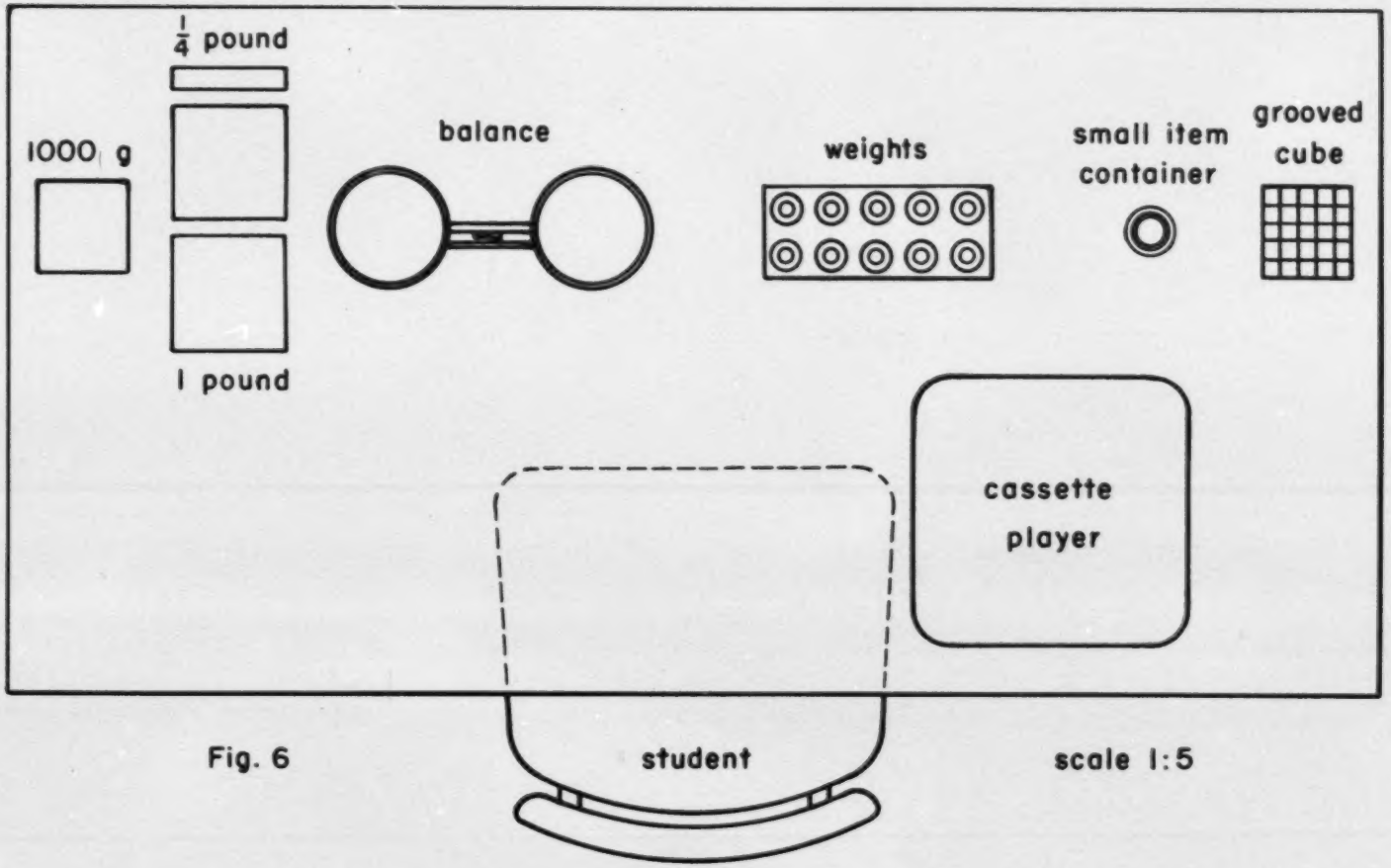

Fig. 6

scale 1:5

22

Figure 6

LEARNING THE METRIC SYSTEM FOR
PERSONS WITH SIGHT IMPAIRMENT

STATION Y - MASS (WEIGHT) AND VOLUME

Pick up C1. It is located on the table to your far left. (THIRTY SECOND PAUSE) This cube is a cubic decimetre that weighs one kilogram or one thousand grams. Keep this unit in front of you after you have used it.

Stop the tape. When you are satisfied that you understand this concept, proceed with the tape.

Pick up C2. (THIRTY SECOND PAUSE) This unit consists of three items. The first two items are packaged in typical one pound butter containers and each weigh exactly one pound. The two of them together weigh two pounds. There is an extra item not quite one quarter of a pound in size. These three items weigh 2.2 pounds or the same as the cubic decimetre, which weighs one kilogram. A kilogram then equals 2.2 pounds. A pound of butter weighs slightly less than one half kilogram or about four hundred fifty-four grams.

Now stop the tape. When you have had time to examine these items, start the tape again.

Place C3 in front of you. (THIRTY SECOND PAUSE) You have before you a balance scale that has a pointer located at the base. Remember that the kilogram is divided into one thousand smaller units called grams.

Now stop the tape. When you are satisfied that you understand the concept, proceed with the tape.

Place C4 in front of you. (THIRTY SECOND PAUSE) This unit consists of a set of small round weight measurements. The weight measurements are marked in front, the smallest unit of which is one gram. This is marked one. Next are two two-gram weights and these are marked two. The next unit is a five-gram weight. The next units are two ten-gram units. The next unit is a twenty-gram weight. The next unit is a fifty-gram weight. On the other side of the holder there are two one hundred-gram weights, one two-hundred gram weight and one five-hundred gram weight. Remember, one gram is about 1/28th of an ounce. For example, a nickel or five cent piece weighs five grams.

Stop the tape. When you have had enough time to examine these items, proceed with the tape.

Place C5 in front of you. (THIRTY SECOND PAUSE) Place the one-gram weight on the right side of the balance scale and the paper clip on the left side. Touch the pointer near the center of the base. You will find that they balance. The paper clip then weighs one gram.

Place the five-gram weight on the right side of the scale and the nickel on the left side. You will find that the scale is balanced. The nickel weighs five grams.

The third item is a small round battery. How much does it weigh?

Stop the tape. When you have had enough time to complete these three weighing activities, start the tape again.

The small battery weighs twenty-five grams.

Pick up D1. (THIRTY SECOND PAUSE) You have already learned about length and area measurement. Now you will learn about volume measurement. The cube you have in your hands is grooved on all six sides. This large cube is a cubic decimetre. You will note that the cube is ten centimetres on each edge. Each of the small cubes formed by the grooves is a cubic centimetre. There are one thousand cubic centimetres in a cubic decimetre. In other words, ten times ten times ten equals one thousand cubic centimetres. This large cube weighs one kilogram. Each of the small cubes would weigh one gram.

This cube illustrates relationships that exist in the metric system. In the metric system there are definite relationships between length, area, volume, liquid capacity and weight. One cubic decimetre equals one litre in fluid volume or capacity. One litre of water weighs about one kilogram. Also a one cubic centimetre container has a fluid capacity of one millilitre and will weigh about one gram if filled with water. In contrast, in the customary system it would take a container with a volume of sixty-one cubic inches to equal 1.06 quarts and this would weigh approximately 2.2 pounds of water.

This concludes the learning activities on weight and volume. After you have stopped the tape, complete the last three learning activities at this station. Then rewind the tape, remove it from the cassette player and

leave it with the rest of the items at this station. You will then proceed to Station Z taking your cassette player with you. When you arrive at Station Z, place the cassette tape in the cassette player and proceed. Now stop the tape and complete these instructions.

TABLE Z

TYPICAL HOME USE ITEMS

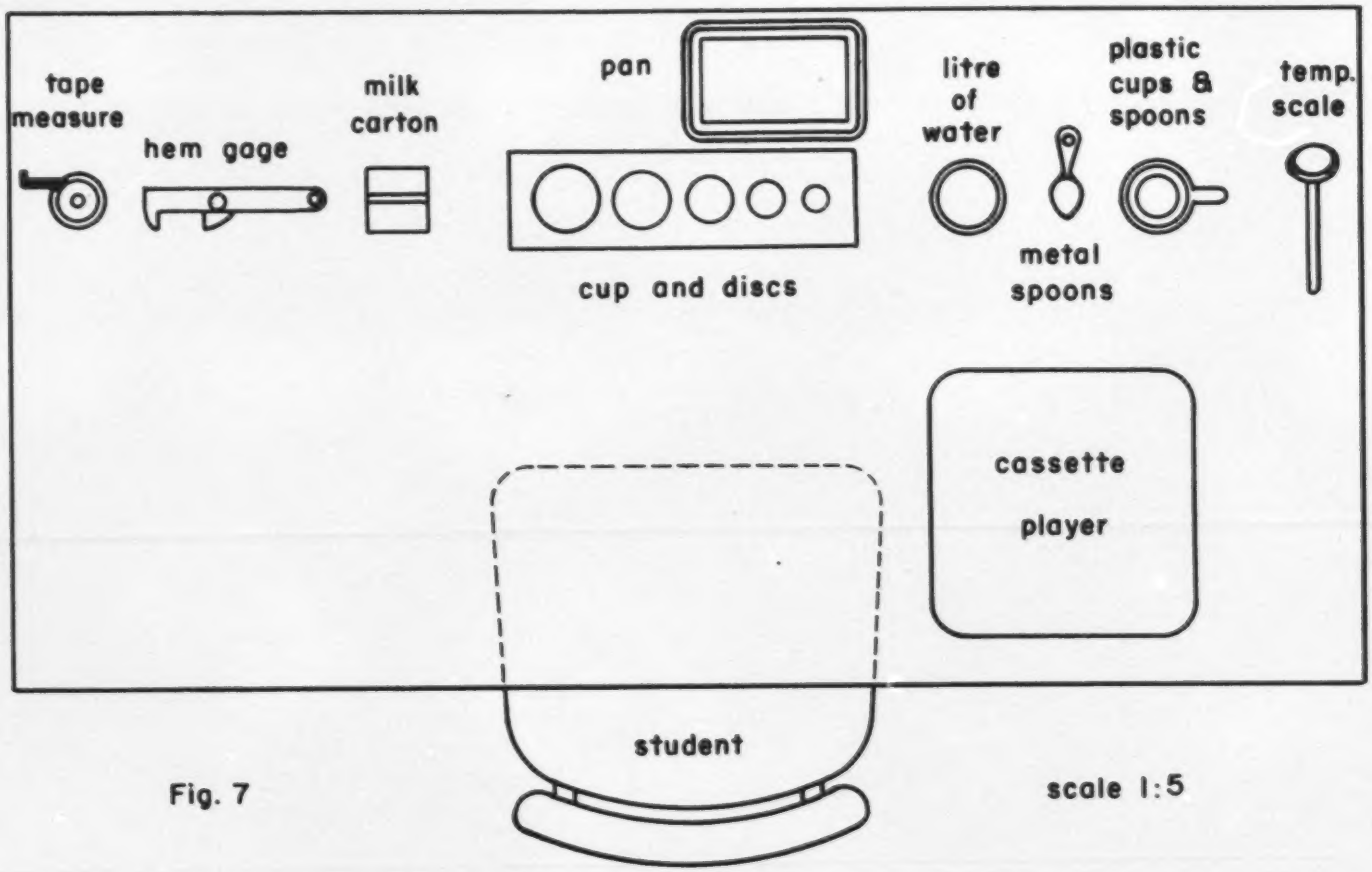

Fig. 7

scale 1:5

Figure 7

LEARNING THE METRIC SYSTEM FOR
PERSONS WITH SIGHT IMPAIRMENT

STATION 2 - COMMON METRIC ITEMS USED IN THE HOME

Pick up E1, which is on the table to your far left. (THIRTY SECOND PAUSE) This is a tape measure that is one hundred fifty centimetres, 1.5 metres or one and one half metres long. The notches on the side of the tape are at every ten millimetres or one centimetre. At every ten centimetre graduation there is a staple. Remember that ten centimetres equal one decimetre and one hundred centimetres or ten decimetres equal one metre.

For clothing and body sizes all measurements will be given in centimetres.

Stop the tape. When you are satisfied that you understand this concept, put this item aside and proceed.

Pick up E2. This item is numbered on the back side. (THIRTY SECOND PAUSE) This hem gage has a sliding plastic stop that can be adjusted to the notches that are at every centimetre.

Stop the tape. When you have had time to examine this item, start the tape again.

Pick up E3. (THIRTY SECOND PAUSE) The cubic decimetre when used for liquid measurement is called a litre. The milk container you have before you has a small section that can be removed. When this section is taken out, you have a quart container. When you add this small section, you have a litre container. Both the litre and the quart container are measured from the top where the taper begins. The litre is about six percent larger than a quart. All liquid measurements will be given in litres. Remember, a litre is about six percent larger than a quart and there are about three and three-fourths litres in a gallon. Therefore, if a gas tank held ten gallons, it will now hold thirty-seven litres. If it held twenty gallons, it will hold about seventy-five litres.

The litre, spelled l i t r e, has a symbol which is a vertical "ell" without a period. However, it is sometimes difficult to tell the difference between an "ell" and a one so the litre is often written out.

The litre is divided into one thousand smaller units

called millilitres. A millilitre is equal to a cubic centimetre. The litre and the millilitre are the units of liquid measurement used for cooking and all kinds of home activities. Fortunately, the common cooking units such as the cup, tablespoon and teaspoon that you now use are so similar in size to the metric cup, tablespoon and teaspoon that there will be little change in the way in which cooking is done.

Now stop the tape. When you have had time to examine this item, start the tape again.

Place E4 in front of you. (THIRTY SECOND PAUSE) Pick up the cup to your left. This is a metric cup, which is two hundred fifty millilitres or the equivalent of one-quarter of a litre. It is only slightly larger than the customary cup, which is equal to two hundred thirty seven millilitres.

To your right are a series of displacement discs that can be used to measure smaller amounts of liquid. The largest displacement disc, when it is put into the cup, will result in a liquid volume of fifty millilitres. The next smaller unit will result in the cup holding one hundred millilitres. The next one will result in the cup holding one hundred fifty millilitres and with the last disc the cup will hold two hundred millilitres.

Now that you know about these displacement discs, you will use them to do a series of experiments. In addition to the cup and discs, there is a pan into which you can place the cup and a litre of water that you can use to do the experiment.

Listen to the directions of what you should do. Do not proceed until you receive the instruction, "Stop the tape and do this experiment."

Place the glass cup in the center of the metal pan. Then place the smallest displacement disc in the cup. Place the index finger of your left hand in the spout of the cup and hold it there. Fill the cup with water until you feel the liquid touch your finger. Remove the displacement disc. You now have two hundred millilitres of fluid in the cup. Empty this back into the container holding the water. Stop the tape and do this experiment.

Repeat the process with the next larger disc. When you remove the disc, the cup will have one hundred fifty millilitres of liquid. Stop the tape and do this experiment.

Repeat the process with the next larger disc. When the disc is removed from the cup, you will have one hundred millilitres in the cup. Stop the tape and do this experiment.

Repeat the process with the next larger disc. When this is removed from the cup, it will contain fifty millilitres of liquid. Stop the tape and do this experiment.

Pick up E5. (THIRTY SECOND PAUSE) This is a set of measuring spoons to be used for liquid measurement. The largest is fifteen millilitres and is called a metric tablespoon. The next largest is five millilitres and is called a metric teaspoon. The next largest is 2.5 millilitres and the smallest one holds 1.25 millilitres.

Now stop the tape. When you have had time to examine these items, start the tape again.

Pick up E6. (THIRTY SECOND PAUSE) This is a set of plastic measuring cups and spoons. The largest cup holds exactly two hundred fifty millilitres. The second largest one hundred twenty five millilitres. The third largest eighty millilitres and the smallest sixty millilitres. You also have a set of measuring spoons. This set is for dry ingredients although they are the same size as those with bent handles.

The customary and metric units for spoons are very, very similar. A metric tablespoon is equal to fifteen millilitres while a customary spoon holds 14.8 millilitres. A metric teaspoon holds five millilitres while a customary teaspoon holds 4.9 millilitres.

Stop the tape. When you are satisfied that you understand these concepts, put these items aside and proceed.

Pick up E7. (THIRTY SECOND PAUSE) The unit of temperature in the metric system is degrees Celsius. On the Celsius scale, which was formerly called centigrade, water freezes at zero and boils at 100°. The average body temperature is 37 °C. This temperature scale replaces the Fahrenheit scale, which you currently use.

For weather temperatures it is easy to remember the comparison between the degrees Celsius and degrees Fahrenheit. Ten degrees Celsius is equal to fifty degrees Fahrenheit. Every nine degree increase in Fahrenheit equals a five degree increase in Celsius. For example, 59 °F equals 15 °C; 68 °F equals 20 °C. A comfortable room would be about 21 or 22 degrees Celsius.

The temperature scale you have in your hands is marked in degrees Celsius. Notice the location of the pointer. There are two bars on the edge of the bezel at 0 °C and a single bar on the edge of the bezel at 100 °C. At every 25° increment there is a short bar.

For cooking temperature the relationship between degrees Fahrenheit and degrees Celsius is very simple. To obtain the correct Celsius temperature just divide the Fahrenheit temperature in half and the result will be approximately right. For example, if the cooking temperature in Fahrenheit is 400 degrees, then it would be 200 degrees Celsius.

This concludes the learning activities on common household items. After you have stopped the tape, rewind it and remove it from the cassette player. Leave it with the otner items at the station.

You have now completed the total program. If you desire, you can repeat any of these activities at any station. We hope that you have learned from these activities and that you are ready to enter the metric world. Good luck.

Now stop the tape and complete these instructions.

Figure 8

EVALUATION FORM FOR LEARNING THE METRIC SYSTEM FOR PERSONS WITH SIGHT IMPAIRMENT

The monitor will ask the participant for the following information. His or her answers will be recorded on cassette tape.

1. Please state your name, address, educational background and career objective.

2. What is your overall opinion of the material on learning metrics?

3. Is the program complete enough for you to understand the common elements of SI metric?

4. What specific suggestions do you have for improving the program?

5. What additional material would you like to see included in this program?

Section 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

This project had four major objectives, namely

1. Make an analysis of four career clusters to determine the kind of metric competency needed in each of five occupations. On the basis of these analyses, a detailed teaching-learning unit was developed for two occupations, carpentry in the career cluster of construction, and machine shop in the career cluster of manufacturing.
2. Prepare instructional material in metrics in the Spanish language.
3. Develop metric instructional materials for persons with reading difficulties.
4. Develop three-dimensional and audio materials for teaching metrics for persons with sight handicaps.*

Part I of this study dealt with the development of curriculum materials in vocational education. In the years ahead all curriculum materials in all areas of career education must be reviewed and rewritten to include the necessary materials on the SI metric measuring system and the application of this measuring system to the tools, materials and processes of that particular occupation or job. In addition, these curriculum materials must include national and international standards as they become available. However, since only approximately a hundred and fifty of the ISO standards are currently available in SI metrics, and because there is a need for approximately 11,000 of these standards, it will be many years before standards are available in all occupational areas. Standards are likely to be available in the broad career clusters of manufacturing much sooner than in the career cluster of construction. It would be a fair estimate to say that it will be many years before all of the standards in construction are available that would make it possible to produce an all-metric home.

Part II of this project dealt with the development

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*See Appendix B

of metric learning materials in Spanish. Within the past years several states have passed legislation requiring schools to offer instruction in more than one language area. In many parts of the country this means that vocational instruction will need to be given in Spanish. Therefore, metric materials will be essential in these programs.

Part III of this project dealt with the development of instructional materials for persons with reading difficulty. Many students enrolled in vocational programs have serious reading difficulties. While it is important for them to improve their reading skills, it is also important to offer instruction that utilizes little or no verbal materials. Since reading abilities are found to be related to job performance, it is important that students who have reading difficulty learn to measure in the metric system as quickly as those who can comprehend written instructional materials. Therefore, the development of these hands-on kits is one attempt to overcome the limitations that printed materials have in teaching metrics to persons with reading difficulty.

Part IV of this project dealt with the development of metric materials for persons with sight handicaps. Another disadvantaged group in our economy who must learn to use measuring instruments are those people with sight handicaps. Therefore, this group needs special types of learning materials by which a student can actually learn to measure by using his sense of touch and hearing.

CONCLUSIONS AND RECOMMENDATIONS

The following are conclusions and recommendations concerning further utilization of these materials.

1. All state and city courses of study in vocational education should be re-evaluated to determine the amount of metrics that should be included in each of these courses of study. Most course materials developed by state and local groups are based to a large extent on the textbooks available in each of these areas. Therefore, until textbooks have been revised to include metrics, it will be difficult to update the course materials. Another problem relating to course materials in vocational education is that many procedures and practices are based on engineering standards. Therefore, until these engineering standards are available based on SI units, it will be impossible to include all these in the current course of instruction.

2. Plans should be made to provide curriculum makers with up-to-date information on metric standards. Some type of newsletter should be established through the U.S. Office of Education or one of its centers that would interpret new industry standards as they become available and make the material available to curriculum planners. As each new standard is published by ISO (International Organization for Standardization) and the ANSI (American National Standards Institute), these materials should be relayed to the curriculum makers. Also, there should be a state library of metric standards available in each state of the Union. Standards are expensive, and therefore, they are not in the budget range of every school. The current one hundred and fifty standards that are measure sensitive cost approximately $1,500. Since roughly 11,000 of these standards will eventually be available, the complete set could be a costly item (up to $10,000) unless some kind of an arrangement could be made to make them available either through state or national distribution.

One possibility might be to include these standards in ERIC providing an arrangement could be made with the American National Standards Institute to reproduce these materials.

3. Inservice training is an essential part of the well-planned, coordinated effort of metric conversion in vocational education. Even though materials are available in metric, they will not be utilized by the teachers unless there is an inservice program that will update the some 150,000 vocational, industrial and industrial education teachers in the United States. Each state has a responsibility of providing some kind of inservice workshop for the technical teachers of all vocational and technical programs. Inservice programs should begin immediately in such areas as drafting and machine shop since these are the first two vocational areas that will be most greatly affected by metric conversion.

4. Metric materials in foreign languages should be made available to those groups who can use these materials. Some method should be devised for better dissemination of the three items developed as part of this project, namely the basic kit, GOING METRIC FOR CAREER TEACHERS; the forty-nine page booklet entitled, THE METRIC SYSTEM FOR EVERYDAY USE; and a Spanish edition of the National Bureau of Standards Special Publication 304A, THE MODERNIZED METRIC SYSTEM.

It was not the responsibility of this study to disseminate these materials, however, since two of the

items were produced in two or more colors, it would make a great deal of sense if some group of organization would take on the responsibility of disseminating these materials on a long-term basis. In the years ahead there will be greater need for the instructional materials than is currently envisioned by most individuals involved in bilingual education. Therefore, either the bilingual education division of the U.S. Office of Education or a similar group should take over the responsibility of making these three items available.

5. Ample funds must be provided in all areas of vocational education to purchase measuring tools and conversion equipment. Metric conversion will never be effective in vocational education until school systems and teachers are provided with the necessary funds to purchase measuring tools and conversion equipment. Metrics in vocational education is a practical and applied subject. For example, unless the drafting students have metric scales and templates, it is impossible for students to actaully learn to make metric drawings. In machine shop a complete set of metric measuring tools and conversion dials and equipment are needed if the students are actually to produce parts in metric measurements.

6. Metric kits developed for persons with reading difficulty should be reproduced on a commercial basis. It is unrealistic to expect school districts or individual schools or teachers to build the hands-on kits that were used in teaching metrics to persons with reading difficulties. Even though drawings and photographs of each of these kits are available in this report, there is a very slight chance that these materials will be used unless they are made available through some commercial source.

7. The three-dimensional material developed for persons with sight handicaps should be produced in quantity by one of the national organizations such as the American Printing House for the Blind or the American Foundation for the Blind and made available at a low cost to all schools and programs involved in teaching the blind. Prototypes of each item as well as photographs and drawings of each appear in this report. In addition, the script for the cassettes to use with these materials is also included. Each of these items are high cost materials. For example, it is estimated that it will cost at least $60 to reproduce the precision three hundred millimetre rule. A complete set of these materials might run into the hundreds of dollars. However, if some organization could subsidize the reproduction of these items, it would be a great benefit to those persons with sight handicaps.

8. The most common weakness of most curriculum projects is the lack of adequate dissemination. While a great deal of time and energy has been expended in developing unique teaching materials in the area of metrics, and while these materials have been evaluated to a limited extent, there are no plans to widely disseminate the material.

9. There should be a follow-up study to refine and re-evaluate the materials for those persons with reading difficulty and the three-dimensional materials for persons with sight handicaps. To make sure that any organization or group can produce these materials, great care and attention was given to producing accurate drawings of all the three-dimensional objects developed in these two aspects of the project.

Appendix A

RESUME

I. Personal

Name: William K. Purdy
Address: 4663 East Alice
Stevensville, MI 49127

Married, One Child, 5' 11", 180 lbs, 37 years old

II. Professional Objective

To teach Vocational Industrial or Industrial Arts Woodworking at the University level, Community College level or Vocational/Technical School level.

Ultimate Goal: To administer Vocational Industrial Programs.

III. Educational Attainment

Western Michigan University, Master of Arts with major in Teaching of Industrial Education, 1971.

Western Michigan University, 1968-1971. Bachelor of Science. Major: Woodworking. Minor: Drafting.

Vocational Certification: State of Michigan, Residential Building Construction.

IV. Work Experience

St. Joseph Public Schools, St. Joseph, Michigan. Building Trades Instructor. September 1975 to Present.

Western Michigan University, Department of Industrial Education, 1971 to 1975. Faculty Member. Taught Courses as Follows: General Woodworking, Machine Woodworking, Upholstering and Wood Turning, Furniture Production, Introduction to Building Trades, Residential Construction, Cabinet Making and Finished Carpentry, Mechanics and Conditioning of Equipment, Industrial Arts for the Elementary Teacher.

Worked for two years as special consultant to the Center for Metric Education, Western Michigan University, in the preparation of teaching materials for educational institutions.

Worked as consultant to the Kent Area Skill Center to prepare visual materials for the Furniture Production and Residentail Construction Departments.

Worked as rough and finish carpenter for Don Upson, Builder, Vicksburg, Michigan.

1963-1968 - Worked for Bartlett Interiors, Charlevoix, Michigan. Work consisted of floor covering of all types, ceramic tile, plastic laminate tops, construction and installation of kitchen cabinets, interior trim such as window and door casings, jambs, hanging doors and sanding and finishing hardwood floors.

1957-1959 - Worked with father in construction of residential dwellings.

Military Service, 1959-1963. United States Navy. Worked as Aircraft Structures Mechanic and Hydraulics Mechanic. Last year during military service served as Quality Control Inspector for aircraft test flights.

V. Professional Qualities

Consistantly recognized during the period at Western Michigan University through student evaluation and honors college letters as being an outstanding instructor.

Wrote an article for Industrial Education Magazine on properly equipping a shop for maintenance. Served on various committees for the Department of Industrial Education, such as Audio-Visual Committee, Woods Area Departmental Committee Chairman of the Student/Faculty Concerns Committee.

Active member of the following professional organizations: Epsilon Pi Tau Fraternity; Michigan Industrial Education Society.

RESUME

Dillon, Seymour Christopher

Born a U.S. Citizen (American father) in Lima, Peru
August 21, 1921

Married to Eleanor Jean Hadley, six children

EDUCATION: Primary and Secondary schools in Lima, Peru. Graduated from Colegio Nacional de Nuestra Senora de Guadalupe, Lima, 1944. Attended University of Washington, Seattle Washington, September 1944 to June 1945. U.S. Military Service--Six week training in Counter Intelligence School, Holabird Signal Depot, Baltimore, Maryland. Further CIS and German language training at European Theater Intelligence School, Oberamergau, Bavaria. Attended University of North Carolina, Chapel Hill, North Carolina, 1947 to August 1950. Earned BA in Spanish Literature, Philosophy minor.

EMPLOYMENT: September 1950 to Present: Worked in various capacities with Clark Equipment Company, Industrial Truck Division. Presently Area Manager for Latin America of Clark International Marketing, S.A., Industrial Truck Division.

September 1947 to September 1950: Teaching Fellow (Spanish) and Secretary to Head of Romance Languages Department, University of North Carolina.

September 1944 to July 1945: Teaching Fellow (Spanish), University of Washington.

1939 to July 1944: Office Boy, Salesman, Translator, Bi-lingual Secretary and Executive Assistant to Managing Director, Automotive Sales Corporation, S.A., Lima, Peru.

VITA

INES GOOD

Born in Bogata, Colombia. Obtained a Resident Visa in 1971. Married to a U.S. Citizen.

EDUCATION

B.A. Degree from Universidad Pedagogica Nacional, Colombia. Major: Languages.

Presently working on Master's Degree, Western Michigan University, Kalamazoo, Michigan. Awarded a temporary Michigan Teaching Certificate in 1972. Will be converted to a permanent certificate upon completion of Master's Degree.

EMPLOYMENT

1975-Present: Spanish Instructor, Monsignor Hackett High School, Kalamazoo, Michigan.

1974-1975: Graduate Assistant, Department of Modern and Classical Languages, Western Michigan University. Taught beginning level Spanish courses.

1967-1971: High School and College English/Spanish Instructor, Universidad Pedagogica Nacional (high school belongs to the University), Colombia. Taught beginning level Spanish and English.

1966-1967: Junior High and High School Exchange Teacher, Dandridge, Tennessee. Taught Spanish courses.

1965-1966: Taught Spanish and English in a small town close to Bogota, Colombia.

VITA

John W. Evers

PERSONAL DATA

Office Address: Department of Research, Development & Evaluation
Madison Public Schools
545 West Dayton Street
Madison, Wisconsin 53703
(608) 266-6013

Home Address: 5502 Century Avenue, Apt. 3
Middleton, Wisconsin 53562
(608) 831-0753

Birthdate: March 22, 1947
Marital Status: Married
Social Security No.: 460-80-0212

EDUCATIONAL RECORD

Western Michigan University, Ed.D. (Educational Evaluation) A.B.D.

Texas A & M University, M.Ed., (Curriculum Development and Educational Psychology), August, 1972.

The Ohio State University, B.S.Ed., (English and Journalism), December, 1969.

EMPLOYMENT HISTORY

Coordinator of Research and Evaluation Information Services, Madison Public Schools, August 1975-present.

Staff Associate for Program Evaluation, The Evaluation Center, Western Michigan University, August 1973-August 1975.

Project Director, Hill Family Foundation's Four-Year Independent College Productivity Program, February 1974-February 1975.

Project Evaluator, EPDA Program for the Management of Educational Change, September 1973-June 1974.

Staff Evaluator, Nissonger Center for Mental Retardation, In-Service Training Unit, Ohio State University, July-August 1973.

Staff Evaluator, Dayton Public Schools, Project PPBES, March-August 1973.

Graduate Research Associate, The Ohio State University Evaluation Center, Model Training Project, Internal Evaluation Unit, August 1972-June 1973.

Research Training Fellowship, National Institute of Education, Washington, D.C., August 1972-August 1974.

Administrative Assistant to Vice President of Business Affairs, Texas A & M University, July 1971-August 1972.

High School English and Creative Writing Teacher, Spring Branch Independent School District, Houston, Texas, January 1969-August 1971.

OTHER PROFESSIONAL EXPERIENCE

Consultant to Illinois State Department of Education, Springfield, Illinois, May 1975 (to evaluate two projects for deaf/blind children).

Consultant to the Center for Metric Education, Western Michigan University, March-June 1975 (to pilot test curriculum materials for slow learners).

Consultant to Vice President for Student Affairs, The Ohio State University, December 1972-February 1973 (to assess evaluation needs).

Consultant to Texas State Department of Education, Austin, Texas, January-March 1971 (to evaluate a pilot test site).

PROFESSIONAL ORGANIZATIONS

American Association of Higher Education
American Educational Research Association
National Council for Measurement in Education

PROFESSIONAL PAPERS

"An Investigation of Goal-Free and Goal-Based Evaluation Strategies through Project Director and Evaluator Ratings", 1975 AERA Annual Meeting, Washington, D.C.

REFERENCES

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Academic Training

BA Indiana University, 1938
MA Teachers' College, Columbia University, 1949
Graduate work in the area of the Visually Handicapped, San Francisco State University
Additional Graduate Study, North Carolina State University, Butler University

Experience

Indiana School for the Blind - Teacher of the Visually Handicapped, 1938-1952
Perkins School for the Blind - Teacher of the Visually Handicapped, 1952-1954
The Governor Morehead School, Raleigh, North Carolina - Teacher of the Visually Handicapped, 1954-1968
North Carolina State Department of Public Instruction - Inservice Training for Teachers, 1960-1968
Converse College, Spartanburg, South Carolina - Methods in Teaching the Blind, Summer, 1963
Montana Summer School for Adult Blind - Director, Summer Adjustment Program for Adult Blind, Summers, 1962, 1964, 1965, 1966, 1967, 1969, 1971
Western Michigan University - Assistant Professor, Blind Rehabilitation, 1968-present
Indiana Agency for the Blind - Staff Training, April, 1972; August, 1973
Georgia State Services for the Blind - Staff Training, April, 1973; July, 1974
North Carolina State University, Summer, 1975

Memberships

Association for the Education of the Visually Handicapped, Chairman, Primary Workshop, 1958-1962; 1968-1970
American Association of Workers for the Blind, Board Member, Michigan Chapter, Member Program Committee, 1971, 1972, 1974
Council for Exceptional Children, 1971-1974
Michigan Federation of the Blind, Secretary, 1970-1974
Michigan Association of the Blind, Secretary, 1972-present

Publications

"The Partially Sighted Child in the School for the Blind," New Outlook for the Blind, 1953

A Curriculum Guide - "The Orientation and Adjustment of Older Visually Handicapped Children," The Governor Morehead School, 1965 (pamphlet 15 pages)

RESUME

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APPENDIX B

Metrics for Visually Impaired Persons

ELIZABETH M. LENNON
JOHN L. FEIRER
WILLIAM K. PURDY
Ms. Lennon is assistant professor, Department of Blind Rehabilitation; Dr. Feirer is professor and head of industrial education and director of the Center for Metric Education; and Mr. Purdy is an instructor, Department of Industrial Education—all at Western Michigan University, Kalamazoo.

Abstract: *The Center for Metric Education at Western Michigan University, under a U.S. Office of Education grant entitled "Metric Conversion in Vocational Education," has developed a number of aids to be used by visually impaired persons in learning and using the metric system. Linear measurements (and their relationships to volume and weight) for general use and measures commonly used in the kitchen have been emphasized.*

■ Metric measurements are going to be the way of life in the not-so-distant future for the residents of the United States, just as they have been for 92 percent of the world's population since the development of the system in France in 1793. Visually impaired consumers, homemakers, hobbyists, and students, just as all others, must be prepared for a future of grams, metres, litres and degrees Celsius. No longer will these units be used only for medical measurements, foreign car gauges, and obtuse scientific instruments. The simple metric system, with its direct relationship between length, volume, and weight and with all units of ten, will be the predominant language of measurement in this country within the next ten to 15 years.

Most people dislike changes and a major problem in converting to a new system of measurement will be the changing of our customary English units of inches and pounds to metric units. Memorizing long conversion tables is neither easy nor necessary. A more appropriate way to learn the new system is to use it—to make it a part of our daily lives in every possible situation. By learning only the basic units as they apply at any given time and not trying to absorb the whole system at once, the task will not be so formidable. The basic unit of length is the metre (m); for volume, the litre (*l* or l); and for mass, the kilogram (kg). All other units that one will need to use in measurement are either multiples or divisions of these by ten, 100, or 1,000.

THE CENTER FOR METRIC EDUCATION To make the transition from our customary system of measures to metrics realistic and practical for the visually impaired, the Center for Metric Education at Western Michigan University, Kalamazoo, under a grant (Metric Conversion in Vocational Education, OEG-O-74-1661) from the United States Office of Education, has developed, adapted, or located various aids and equipment that can be used to teach those who must depend on touch rather than sight in making measurements. By using these devices and the accompanying instruments, the gourmet cook, the seamstress, the wood or metal worker who is blind can make an easy changeover from our present English system of measure to the simple metric system.

To compare the metre, the basic unit of length in the metric system, with the yard, two bars are used. (See Figure 1 for various linear measurement devices.) It is readily apparent that the metre is about one tenth (3.17 inches) longer than the yard. Since all units are multiples of ten, another metre stick is divided by tangible grooves into ten parts called decimetres (dm), each about four inches long. Still another bar is separated into 100 smaller units known as centimetres (cm). Centimetres, in turn, are divided into ten parts each, which are known as millimetres (mm). Thus, there are 1,000 millimetres in a metre (10 × 10 × 10). For everyday use in measuring cloth and body parts, the centimetre can be used. However, the millimetre is the unit used for all industrial work. It is about the thickness of a dime or 1/25 of an inch.

An abacus is available to demonstrate the length of a millimetre. When ten millimetre rods are brought together, we have a centimetre of 0.4 inches—a little less than half an inch. For the shop craftsman an aluminum rod, threaded to millimetres, is available for either measuring or marking. One complete turn of a nut, fitted to the rod equals one millimetre. Ten turns equals a centimetre, marked by a single sharp thread. A second nut can be used to set a desired dimension.

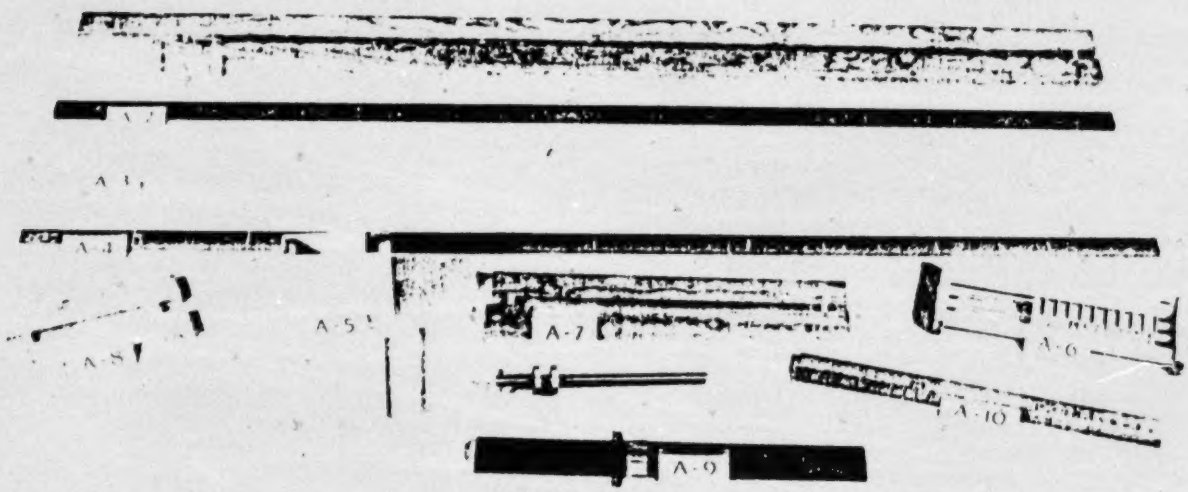

Figure 1. Various Linear Measurement Devices

A-1 Comparative unit for metre and yard
A-2 Plastic metre stick
A-3 Metre marked in centimetres
A-4 Metre marked in decimetres
A-5 Decimetre segments which equal one metre
A-6 Device to show relationship between millimetres and centimetres; each piece is one millimetre thick
A-7 Comparative unit for 300 mm and one foot
A-8 Comparative unit for 150 mm and six inches
A-9 300 mm rule with markings at each centimetre
A-10 Technical rule 300 mm long; each marking is 2 mm with centimetre markings slightly longer to facilitate reading; braille numbers mark the first ten centimetres

Figure 2. Comparison of Weight and Mass Using Common Items Such as Butter.

The 300 millimetre ruler is the one commonly used in metric measurements. A comparable customary ruler shows this 300 mm. rule to be slightly shorter than a foot in length. There is an inexpensive grooved plastic rule, available in many office supply stores, on one side of which is the customary system and on the other the metric. The metric edge is divided into five millimetre segments, with longer lines at every ten millimetres (one centimetre). A precision measuring rule, with a tapered edge indented at each two millimetres is 30 centimetres (30 cm) or 300 millimetres (300 mm) in length. There are long indented lines at each centimetre marked with braille numbers. Even though the numbers are at centimetre lines, for precision measuring they would be referred to in millimetres.

Additional comparative units of length that have been developed show that a six-inch rule is slightly longer than one containing 150 millimetres (150 mm), that an inch is about 2½ times as long as a centimetre, and that four square inches is slightly larger than one square decimetre. All of these can be examined and related, one to another, by touch.

Not easy to demonstrate in tangible form, but of considerable interest to many visually impaired persons is the kilometre (km) or 1,000 metres. Used for measuring distances between cities, speed limits, and the like, a kilometre is equal to approximately 6/10 of a mile. Thus, our present highway speed limit of 55 miles an hour would be about 88 kilometres an hour in metric language.

LENGTH, VOLUME, WEIGHT In the metric system, there is a definite relationship between length, volume, liquid capacity and weight or mass. This is illustrated by a stack of ten squares, each one centimetre thick and one decimetre long on each side (see Figure 2). Each block has an area of one square decimetre (1 dm^2). When these blocks are stacked one on top of another, they form one cubic decimetre (dm^3)—ten centimetres equal one decimetre. If this were an open container, it would be called a litre (*l* or l) for liquid measurement; if it were filled with water, it would weight one kilogram (kg). The ten blocks together do weigh one kilogram. Another aid to teach volume-weight measurement is a cubic decimetre (dm^3) divided by grooves into ten centimetres on each side or 1,000 cubic centimetres in the cubic decimetre (10 x 10 x 10).

The cubic decimetre divided into centimetres, described above, makes for easy transition to metric weights, for the weight of the amount of water in one cubic centimetre (1 cm^3) container is the metric unit of weight or one gram (1 g). One thousand grams make one kilogram. To compare the cubic decimetre and the kilogram with our customary system of weights, two conventional pound packages of butter and one smaller piece—not quite one-fourth pound—are used. These, which together weigh 2.2 pounds, are exactly the same in size and weight as the cubic decimetre which weighs one kilogram or 1,000 grams.

A balance scale, with weights of one, two, five, ten, 20, 50, 200, and 500 grams, all marked in braille, can be used to compare our customary ounces and pounds with metric grams. A paper clip weighs one gram; a nickel, five grams.

Comparing Liquid Measures

To compare liquid measures, a quart milk container is fitted with a small section on top. When the section is removed, we have a quart, when it is put back on, we have a litre. The litre is about six percent larger than the quart, and there are about 3¾ litres in a gallon. Thus, a purchase of ten gallons of gasoline would contain 37 litres. The two most commonly used units of liquid measure used in cooking are the litre (*l* or l) and the millilitre (ml)—one thousandth of a litre. Fortunately, the measures we now use in the kitchen are so similar in amounts to metric measures that there will be little difficulty in using favorite recipes.

The metric cup, containing 250 millilitres (250 ml) or one-fourth litre is only slightly larger than the customary cup measure. To make the exact measurement of liquids easy for the blind homemaker, a series of four displacement units have been developed. If the largest unit is placed in a measuring cup when it is partly filled with liquid, enough liquid will overflow so that only 50 millilitres (50 ml) will remain in the cup. Other units can be used in a similar manner to exactly measure 100, 150, and 200 millilitres of liquid.

Measuring Cups and Spoons

Already on the market are the individual graduated metric measuring cups and spoons, both in metal and plastic, that are the mainstay of the blind cook. At the Center for Metric Education, sets of cups have been marked in braille—one cup holding 250 millilitres, one-half cup or 125 millilitres, one-third cup or 80 millilitres, and one-fourth cup or 60 millilitres. Because it is more convenient for the visually impaired cook, when measuring small quantities of liquid, to dip rather than pour, handles on a set of spoons have been bent so that they resemble small dippers. The units we now use for spoons and the metric units are very nearly the same. The tablespoons is equal to 15 millilitres (15 ml), the teaspoon to five millilitres (5 ml), 1/2 teaspoon to 2.5 millilitres (2.5 ml), and 1/4 teaspoon to 1.25 millilitres (1.25 ml). Braille markings have been placed on the handles of the spoons, but the new system is so simple and logical that these would probably not be needed by most blind cooks.

Available at fabric shops and sewing centers are metric tape measures, skirt markers, and seam ganges. The Center for Metric Education has demonstrated that these can be easily adapted for use by the blind seamstress. With staples to mark decimetres and notches at the centimetres on the tape measure and notches on the skirt marker and seam gauge at centimetre intervals, all of these can be read by touch.

CELSIUS TEMPERATURE Temperatures in the metric system are measured in degrees Celsius (°C) where water freezes at zero degrees and boils at 100 degrees. It is easy to compare our present Fahrenheit scale with degrees Celsius for weather temperature if we remember that a nine-degree increase in the former scale is equal to a five-degree increase in the Celsius scale. Starting at 10°C which equals 50°F, a temperature of 15°C would equal 59°F. Normal body temperature in degrees Celsius is 37 degrees. Our homes will probably be comfortable at 21° or 22°C. Notches filed at several crucial points into the rim of a Celsius stove-top thermometer make it possible to accurately determine the location of the pointer by touch. In cooking, a fairly accurate degree Celsius temperature can be determined by cutting the Fahrenheit temperature in half—for example, an oven setting of 400°F would be approximately 200°C.

The various teaching aids for the visually impaired that have been made at the Center for Metric Education (Figure 3) are described on a tape recording. Explanations are given on how each item can be used and, in addition, the listener is

instructed in the metric measures applicable to each device and the comparison of these with our customary units of measure. Thus, through examining, experimenting, comparing, and listening, metrics can become a way of life for the visually impaired without the tedious memorization of tables and terms.

Resources

American Foundation for the Blind
15 West 16th Street
New York, New York 10011

American Printing House for the Blind
1839 Frankfort Avenue
Louisville, Kentucky 40206

Corning Glass Works
Corning, New York 14830

Foley Manufacturing Company
3300 N.E. Fifth Street
Minneapolis, Minnesota 55418

Martin Burns and Company, Inc.
Hardware and Electrical Wholesalers
7-17 Allen Street
Wellington, New Zealand

Orco Products, Inc.
Dayton, Ohio 45404

Center for Metric Education
Western Michigan University
Kalamazoo, Michigan 49008

Figure 3. Various Household Metric Measuring Devices

E-1 Tape measure with notches at each centimetre and staples at each decimetre
E-2 Hem gauge marked with notches at each centimetre
E-3 Comparative unit to compare litre and quart
E-4 250 ml measuring cup with displacement cones
E-5 Liquid measuring spoons
E-6 Measuring spoons and cups for dry measure
E-7 Temperature scale for cooking, marked in 25-degree Celsius increments; this scale is equipped with a clamp to hold it on pots and pans; it may also be used in meat

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